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THE JOURNAL OF PROSTHETIC DENTISTRY

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THROUGH THE EYES OF THE EDITOR

Reuben N. Albinson discusses the foundation on which dentures rest and the relation of denture bases to this foundation. He feels that changes in the bases themselves account for much denture difficulty. He suggests that mucostatics is the solution since it provided a "tissue base constant." Since mucostatics makes use of metal bases, it does have the advantage of duplicating the impression accurately. It does not, however, stop the normal physiologic processes of living tissues which react to pressure. It does not prevent the blood from leaving the blood vessels contained in the tissues, and it does not prevent the normal changes in bone which follow the extraction of teeth. One important factor in denture shape is ignored. The polished surfaces of dentures as described by Fish and by Tuckfield can be helpful in the maintenance of the position of the dentures. Also, the flanges of dentures have a function which was not mentioned. They are necessary for the proper support of the soft tissues around the mouth for esthetics. There can be no question of the value of balanced occlusion to denture stability regardless of the impression procedure used.

W. J. Tuckfield has discussed the problem of the mandibular denture. He points out that it is a problem to the patient but should not be a technical problem to the dentist. He distinguishes between "retention" and "stability" of dentures. He is correct in saying that stability is more important than retention for satisfactory denture service. He is also correct in saying that the so-called "short-cuts" are economically unsound. His interpretation of Fish's classification of the surfaces of dentures should be most helpful. He points out the value of full and well-rounded margins on dentures. This factor is overlooked in some impression procedures. There can be no criticism of his intent to cover the maximum surface possible. However, he seems to wish to avoid an extension of the lingual flange below the level of the mylohyoid ridge. This does not conform to his stated objective.

Tuckfield attaches the greatest importance to the occlusal surface. This is as it should be because improper occlusal forces can destroy the stability and retention of any denture, even one with perfect adaptation to the supporting tissues, and with a perfect marginal outline. His designation of two different vertical dimensions is significant. There is no disagreement with his suggestion that unilateral balance is essential, but he seems to underestimate the importance of a bilateral balance which is of most value when the patient is not masticating food. We do not agree that Carborundum paste should be used in the mouth to perfect occlusion except when cuspless teeth are used.

William A. Colburn favors the use of plaster of Paris in stock trays for impressions of the edentulous mouth. He claims that this material will record the soft tissue form with great accuracy and with a mini-

mum of tissue displacement. We have observed that considerably more skill is required to make a good full plaster impression than is required to make a plaster wash impression in an individual tray. We doubt the advisability of turning to a more exacting technique, even though the pioneers of modern dentistry used it successfully. The excessive beading of casts which Colburn suggests is also open to question. He does point out a common problem in relining dentures and makes the good suggestion that the dentures be remade on new impressions rather than to reline the dentures.

L. E. Kurth has described a simple and extremely accurate method for checking the accuracy of articulator adjustments and cast mounting on articulators. It is a modification of the Needles' split cast technique. Plaster checkbites are probably more reliable and accurate than wax or modeling compound checkbites for this purpose, although he suggests that any of them can be used.

Reuben N. Albinson emphasizes the importance of an articulator in the construction of dentures. He points out that inaccurate jaw relation records and inaccurate articulators should be discarded. He recommends the use of wax bites with a hinge closure for testing the records and the articulator. We suggest that if the word "bite" is used in the instructions to the patient, the desired record is most difficult to obtain. Too often the word "bite" causes the patient to protrude as he closes. The term "checkbite" is much better because the word refers to a record and not to an instruction or an action.

The testing of the articulator by series of checkbites made at various levels of vertical closure would seem to illustrate that there is a hinge closure. The use of wax for these records might be open to some criticism. Perhaps plaster of Paris would be more accurate. Also, the errors might show up more clearly by the Needles' split cast method of testing articulators.

No test is suggested for eccentric jaw positions. If balanced occlusion in eccentric jaw positions is to be developed, the articulator should be tested for adaptability to records of these jaw relations.

Ronald J. G. Grewcock has made a survey of the principles involved in the establishment of balanced occlusion. He describes four main factors for consideration which form a sound basis for the study. His plan of treatment of occlusal disharmony is based upon an accurate occlusal analysis. It is unfortunate that this is not done by all who attempt to treat occlusal disharmony by selective grinding. The most important phase of occlusal analysis is the determination of the existing tooth and incline plane relations when the jaws are in *centric relation.* Too many dentists accept the "habitual centric occlusion" as the basis for selective grinding. The techniques for obtaining balanced occlusion seem to be correctly worked out.

Robert B. Sloane and Jack Cook have suggested a new guide to the orientation of the plane of occlusion that is based upon anatomic landmarks. After the landmarks were located on the skull, they were translated to landmarks on the upper cast. An instrument was devised to locate and analyze the landmarks on casts for a practical method of locating the occlusal plane. This is done by relating the occlusal plane to Cook's plane which the authors claim to be constant within limited variations. Some additional variations are required for mechanical reasons.

William G. Maison has discussed the preparation of the mouth for immediate dentures. He has specified the operations to be done in the mouth and related them to operations to be done on the cast. This correlation of the work of the dentist and the technician is stressed in such a way as to be helpful to both. The various conditions which may require treatment are classified, and the indicated treatment for each condition in each class is described for the mouth and on the cast. Some of the surgery he suggests, such as the removal of large tuberosities and tori, might be done better and with more satisfactory results, if it is done *before* the immediate denture is started.

The suggested placement of posterior teeth to produce a distal thrust at right angles to a curved lower ridge will hardly produce

the desired effect. Any curve in the occlusal plane should be developed in order to simplify balanced occlusion. It seems more effective to omit one or more pairs of teeth to keep pressures off the inclined lower ridge. The suggested "postdam" seems to be too broad, and there is a definite question as to the value or even the advisability of the "palatal seal."

A. Yurkstas and William A. Curby report the results of their experiments on the force required to masticate food. The measurements were made by means of variable-inductance strain gauges which were incorporated into posterior teeth. Some of the foods required surprising amounts of force. The results seem to show that some prosthetic patients may be unjustly critical of their dentures. It is interesting to note the distribution of various foods to selected teeth for mastication.

Oscar E. Beder has made an evaluation of circumferential clasps and has suggested some procedures to make them more efficient and more easily used. He believes that the lingual arm of the clasp should be nonretentive while the buccal arm should provide all the retention. The lingual arm is then a stabilizing arm which provided reciprocal action during the insertion and removal of the appliance. He recommends modification of the abutment teeth to make this possible. A practical technique for this modification is described.

Miles R. Markley has written a comprehensive discussion of the application of sound principles to the field of restorative dentistry. It is based upon G. V. Black's principles of restorative dentistry. He does suggest some minor changes in Black's principles in the light of present-day practice. He then suggests some basic principles which will improve dental service to the public, if they are followed. He points out the importance of preventive dentistry and of absolute honesty and integrity on the part of every dentist in rendering professional services to the public.

Julius Caplan discusses the protection of teeth during and after their preparation. The recommendation that excessive heat be avoided by the use of a water spray is good. Various types of protective coatings are considered, and a simple technique is suggested for making temporary restorations.

Mortimer C. Davis discusses the requirements of a good technique for making fixed bridges and compares the advantages and disadvantages of some techniques. He describes a very clever direct technique for making a fixed bridge. It certainly has some advantages of the indirect techniques. However, it seems that it would require the ultimate in skill for its accomplishment. The elimination of casts for assembly would seem to avoid some inaccuracy of other methods if it is done properly.

H. D. Grubb discusses certain procedures in fixed bridgework which he has found to be satisfactory and stable. He points out the importance of a thorough diagnosis and describes the procedure he follows. He tells the reasons for his decisions in the choice of materials, retainers, preparations, and methods of making wax patterns for restorations.

Theodore S. Sloane emphasizes the importance of the location of the hinge axis of the mandible and of proper load distribution in his discussion of mouth reconstruction. He illustrates his procedures by the case histories of three patients.

—Carl O. Boucher

THE TISSUE BASE CONSTANT

REUBEN N. ALBINSON, D.D.S.

Minneapolis, Minn.

ANY DENTAL group asked to name the most serious mistake in the articulation of teeth for full or partial dentures would probably offer a variety of answers. Failure to record or maintain "centric relation" would be a popular response. Poor "balance" would run a close second. There would be emphasis on incorrect vertical dimension, disregard of physiologic rest position and free-way space, careless occlusal planes and curves, and the wrong choice of a type of tooth. Meanwhile, it would be safe to wager that an almost universal error would be skipped entirely. It is an error that stultifies perfection in any or all of the above phases. Yet it is rarely considered even after it has been named, explained, and emphasized. We refer to what Dykins[1] so aptly called "the tissue base constant."

Only a negligible per cent of partial or full dentures are articulated over tissue-constant denture bases. This is evident just from a casual study of prevailing curricular and extracurricular clinical procedures. Almost all prostheses are articulated upon baseplates. Some of these are lined with impressions of the casts in a laudable attempt to obtain a better fit. Most of them, however, are articulated over simple and indifferently fitted shells. They go from bad to worse with the pull of heated wax occlusion rims that must be applied. Under such an influence, they warp extensively. This applies to the fitted type as well, and without much difference in degree. In addition, even with normal usage, fitted baseplates lose parts of their lining by chipping and crumbling.

Even if it were possible to maintain perfectly fitted baseplates during the articulating process, it is still necessary to transfer the teeth to another and totally unrelated type of base in the finished denture. Usually, this is a plastic. It infers no criticism of skills nor disparagement of effort to point out that it is impossible to transfer from one type of base to another without introducing some change in tissue base position. The constant is lost. Clearly, even a perfect articulation on baseplates cannot help but be completely out of gear when a case is finished under these conditions.

The question of materials stability is also pertinent to the discussion. It is no secret to be kept hushed nor is it impertinent to remind prosthodontic preceptors that plastics are still tricky. If they emerge from the flask with reasonable fidelity, they continue to be susceptible to warpage from shaping and polishing. Ample experience in the field substantiates the contention of

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dentistry's acknowledged research authorities that there is scant likelihood, at present, of avoiding these discrepancies. In a few words, this means that, operating under such handicaps, malarticulation is a foregone conclusion. Plainly, it is important to dentistry and vital to the health of the public it serves to find a way around these barriers. This is not so difficult as it may seem. The answer may be found in mucostatics.

MUCOSTATICS

Mucostatics entered the impression field in 1938 as a principle rather than a technique. No more techniques were needed. Prosthodontists from one corner of the country to the other had been and were still flooding the profession with impression techniques. All were based upon some modification of the then almost universally accepted concept involving "compression" of soft tissue and the "relief" of hard tissue. It was held sound practice to place soft tissue in some "functional position." Retention was regarded as *the* paramount problem. All sorts of devices from beaded "peripheral seals" to rubber suction cups were in general application. Meanwhile, it was plain that no one was satisfied. The mass of dentistry regularly surged eagerly forward to welcome some new offering and just as regularly turned away in disappointment and headed for another. There was considerable quiet fluctuation in technique among the clinicians themselves.

The first job for mucostatics was proof or disproof of the premises upon which these techniques were founded. A new building cannot be erected upon an old site without first clearing the debris. If the standard concepts were sound, there was no reason why thousands of dentists should be unable to produce maximum and consistently successful results. Yet, such results were noticeable chiefly for their sparsity. The situation was well covered by a contemporary quip, "We have our accidental successes and our scientific failures."

It required but little study in hydrostatics to show that human tissue was amenable neither to compression nor relief under prosthodontic loads. Thus, the main prosthodontic concept was in error. From this point, mucostatics proceeded to move from one orthodox premise to another. The almost monotonous verdict was "not valid." From it all, there quickly emerged a concept based upon premises that were almost the complete opposite of beliefs contemporary with that time.

Since it was impossible to compress even the softest tissue, and since there was no point in the mere creation of space over bony tissue, a sensible course pointed to encapsulation of both hard and soft tissues in their normal, passive form. The primary tenet of mucostatics insisted that we could do no more and certainly should do no less than obtain an accurate negative of the ridge tissues just as they existed in the mouth. Strange as it may seem to the thousands who now accept the natural tissue position as the unquestioned seat for a denture base, the idea was soundly ridiculed. It was months before anyone could be persuaded to try it. Most of the skepticism centered around one point.

It was not hard to convince the profession that tissue could not be "compressed" in the strict sense of the word. What took endless persuasion to gain conviction was the premise that soft tissue would not "give" when a masticating load was imposed upon a denture base that was properly fitted to a natural tissue form. Oddly enough, this constituted rejection of the one concept wherein lay the only hope for prosthodontic success. If it were wrong, no technique would be worth the trouble of a discussion. Those who still argue this point are only admitting that all prosthesis is hopeless. Fitted denture bases would be an impossibility. Articulation would be a joke. There could be no tissue base constant.

Once built, a denture base has an unchanging shape. It takes no heavy reasoning to see that a constantly changing tissue shape could never fit a base with a permanent form. Proper fit could occur under one condition only. The masticating stress would need to be always exactly the same as the impression force from which the impression and subsequent denture base shape resulted. If the patient bit harder or softer or concentrated the force on one side of the jaws, the base would be out of apposition with the moving tissues. As for articulation, it hardly need be said that it would be impossible to articulate teeth based upon sofa pillows. Fortunately, it is not necessary to accept such defeat. That soft tissue can be rendered solid under a mucostatic base has long been an established fact.

Lately, this soft tissue solidity against a direct load has been acknowledged by one of the opposition. At the same time, a corollary statement has been made that mucostatic proponents do not comprehend that movement can still occur because the entire mass consisting of the denture and encapsulated tissue can move sidewise as a unit. Quite to the contrary, this was not only recognized by mucostatics at the outset but also the remedy was indicated. It was pointed out that to stop this unitary sidewise movement is the function of the denture flanges. It is also their function to stop the denture from skidding on the tissues, something that surface tension is helpless to prevent. It has been emphasized and re-emphasized that this is the *only* function of the flanges. Their ". . .depth, detail and outline form have no value. . ."[2] for anything else. In the absence of flanges, surface irregularities that lie close to bony sections of the ridges or palate are equally effective.

It has been consistently pointed out by mucostatics that it is because of possible sideway that the upper denture is far more difficult a problem than the lower. Here, the flanges are in the wrong position to do their job efficiently while the bone that lies close to the lingual flanges on the lower denture may be buried deep on the upper denture. The upper denture is, therefore, mechanically unsound. The real remedy for upper denture stability lies not in the impression but in the articulation. But, to repeat what was said earlier, it is impossible to obtain and maintain articulation without a tissue base constant.

Since the shift from baseplates in articulation to foreign bases in the finished dentures defeats the tissue base constant, then there is only one alternative. We

must use the same base in the finished case that was used while articulating the teeth. There are only two types of bases that have, so far, proved themselves suitable. One is vulcanite. This is not only accurate but also is amenable to double vulcanization with continued accuracy. The other is metal with a plastic superstructure. Since rubber is no longer accepted by patients unless it be in backward areas, metal becomes the only and unavoidable modern choice.

It was not and it is not the intention of this brief paper to start any controversy over which metal is or is not most suitable for a mucostatic base. Having tested metals for years on full and claspless partial mucostatic bases, we have long ago made our choice. That, however, is *our* choice and need not influence anyone else one way or the other. This does not mean that we are closed to argument unless it be those arguments we have been forced to hear so many times that they have become tiresome. Questions on cost we do not care to answer at all. When considered in the light of honest therapeutics, cost becomes a matter of the individual dentist's appreciation of values and his conscience.

On betterments, we hope we are not asleep to possible advancements in science. We shall welcome any proved idea but we do not care to be a testing laboratory for nebulous theories. We are sufficiently engrossed in our own problems and have little time for cooking the chestnuts of others. Meanwhile, there is one idea that we have proved so many thousand times that its validity can no longer be questioned in any way. We refer to the mucostatic principle[2]: "Lasting stability demands an impression and denture base that are accurate negatives of the ridge tissues in their normal, passive form." It is well worth noting that the mucostatic principle has never stopped with just an impression. It has always insisted upon including the denture base as well; something made to order for the tissue base constant. A mucostatic base, coupled with real articulation, spells lasting comfort, efficiency, unsurpassed esthetics, and, what is more important than all of these, tissue preservation for the edentulous and semiedentulous patient.

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THE PROBLEM OF THE MANDIBULAR DENTURE

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WE SO often hear it said that the mandibular denture is a problem. What is this problem, and to whom is it a problem?

It may appear to be a problem to the patient, for many patients find their mandibular dentures difficult to wear. In fact, many expect when they attend the dentist to experience a difficulty with this denture, and there are two reasons for this expectation: (1) They probably know of some friend or neighbor who has experienced difficulty. (2) They perhaps have heard dentists say that this denture is never as satisfactory as the maxillary denture.

Now, *is* there a real problem? In so far as the patient is concerned there appears to be one, but I consider that for the dentist there rarely should be any particular technical problem.

It is not correct to say that as a part of a set of full dentures the maxillary denture is a success if the mandibular denture will not function with it. How can the maxillary denture be satisfactory if the patient cannot masticate his food? Actually, in many cases, it is a lack of satisfactory occlusion between the mandibular and maxillary dentures which causes the mandibular denture to be a failure, and were it not necessary to masticate food, many unsatisfactory mandibular dentures might be quite satisfactory. However, owing to the fact that there is a better retention in the case of the maxillary denture because of the large palatal area, the maxillary denture often stays in situ, despite faulty occlusion, while the poor unfortunate mandibular denture, often having to rest upon a very poor ridge or no ridge at all and having no large palatal surface for retentive purposes, moves about and becomes mixed up with the food the patient is attempting to masticate.

A maxillary denture cannot possibly be satisfactory, no matter how comfortable it may be, nor how strongly it is retained, unless, when masticatory movements are carried out, both dentures are stable and remain in situ. So I contend that there is not merely a problem of making a satisfactory mandibular denture—the problem involved is to make full maxillary and mandibular dentures which will function as a pair.

Read before the Australian Dental Association, New South Wales Branch, April 24, 1951.
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Is the mandibular denture a real problem? For the patient we have acknowledged that it is, but for the dentist I content there should rarely be a technical problem. I am also prepared to go a step farther and say that when a patient presents for full dentures, and there is excessive absorption of the maxillary ridge, a flat vault which is very hard and with little submucosal tissue, the construction of a satisfactory maxillary denture may be a much more difficult proposition than the construction of the majority of mandibular dentures.

I firmly believe that if each practitioner took his responsibilities seriously and conscientiously, there would be no specific problem in the mandibular denture either for himself or the patient. I know that the mandibular denture does not as a rule have the same degree of retention as the maxillary one, but retention, as such, is not so important for the mandibular denture. When the mouth is open and when no function is being performed, a maxillary denture not having retention falls, much to the embarrassment of the patient, but the mandibular denture remains more or less in situ, retention or no. That retentive force, so loosely termed "suction," is necessary for maxillary dentures but not for the mandibular denture.

There is a difference between the terms "retention" and "stability." Retention, as related to artificial dentures, is the resistance offered to a force directed at right angles to the seating surface which tends to lift the denture from the supporting surface of the tissues.

Stability refers to the maintenance of equilibrium and to the resistance to displacement when masticatory forces act, in general, towards the seating surfaces.

Retention is largely dependent upon the impression and the periphery of the denture. Stability is only partly and, comparatively speaking, only in small measure related to the impression, but it is largely dependent upon the establishment of the correct vertical dimension, the shape of the polished surfaces, the tooth placement in relation to the ridges, the balanced occlusion, and freedom from cuspal interference.

Stability is the all-important requisite for the mandibular denture, and this is not dependent upon suction but on other factors, some of which I have mentioned and all of which will be discussed later.

I shall acknowledge, despite what I have said to the contrary, that there is a problem to the dentist regarding the mandibular denture as part of the complete set of dentures but, it is not in the majority of cases a technical problem. It is an economic one or, perhaps to be more correct, it is a pseudo-economic problem.

As I have already indicated, one denture of a full set cannot be satisfactory unless both function together, and the problem then is to make both satisfactory. Because the mandibular denture rarely has the same retention as the maxillary one, the greatest care must be taken in the designing of the mandibular denture, and adequate *time* must be expended on its construction. Every single factor concerned with its stability must be studied and be given due consideration. Should any compromises be necessary, as between the maxillary and mandibular dentures, all must be in favor of the latter.

I have made the statement, that the problem is an economic one, and from this point of view I have often discussed with practitioners the time and trouble required

for successful denture construction. The retort has frequently been, "I cannot afford, for the fee I receive, to take the extra time that would be necessary to muscle-trim my impressions; to check and recheck vertical dimension, centric and eccentric relationships; to provide for balanced occlusion, and so forth." This I counter by saying, "It is the responsibility of the dentist to provide the patient with dentures which will satisfy the requirements of esthetics, phonetics, comfort, and utility." The last is the most important, that is, the dentures must enable the patient to masticate his food with a reasonable degree of efficiency.

If this responsibility be recognized, then you must use all the knowledge and skill you possess and take whatever time may be necessary, so that you will insert dentures which fulfill the requirements; otherwise you are not carrying out your obligations as a professional man.

The fee charged the patient is the dentist's own individual business. It should be in accordance with what he personally considers will compensate him for his time and effort and for the knowledge and skill he puts into the construction of the dentures. My point is that, irrespective of what fee is quoted, the dentist enters into a contract to do his best to supply satisfactory artificial dentures, and the size of the fee has nothing whatever to do with the responsibility he assumes in making the contract. Furthermore, irrespective of the fee, it pays dividends to spend whatever time may be necessary to make the dentures satisfactory without the necessity for undue time to be spent after the insertion of the dentures.

Let us suppose that to lessen the construction costs you take short cuts, perhaps when making the impressions, or by the use of a plain line articulator, or in some other way. You may have a patient who is very cooperative and who considers that wearing new dentures is like wearing a pair of new stiff shoes. He may be patient, suffer a degree of inconvenience, discomfort, and maybe pain. Eventually he may learn to juggle with his dentures and chop his food sufficiently well to avoid immediate digestive trouble, and as a result you "get away with it!" However, every now and then it will be found that a patient just cannot adjust himself to his dentures, and there is trouble for both dentist and patient.

Even the first type of patient (who does eventually learn to eat all over again and to chop his food) may have to come back again and again for adjustments, and often such visits occur just when you are in the midst of some intricate operation or difficult filling. This inconveniences you, but you take a little off here and a little off there to relieve some sore spots, and these little adjustments may spoil the dentures and lead to the necessity for the rebasing or relining of one or the other of them. However, whether it comes to this stage or not, these visits are all time-absorbing, and time means money.

Had all this time spent on adjustments after the insertion of the dentures been utilized when making impressions, establishing vertical dimension, articulating the teeth, shaping the dentures, and the like, only an odd visit or two might have been necessary. Of course it is quite possible that the sum of the time spent in each of these suppositious cases might have been approximately equal, but there is a difference. In the case where considerable additional time had to be spent after the insertion of the dentures, it is quite conceivable that the patient would not have

been pleased with the inconvenience, discomfort, and the irritation caused by the necessity for so many postinsertion visits. In the case where the additional time had been spent prior to the insertion and little postinsertion adjustments had been required, the patient would have been more inclined to sing your praises to friends and neighbors, resulting in new patient recommendations which actually constitute part of your reward. Comfort in the first day or two is so impressive.

As an actual fact, however, in cases where considerable postinsertion visits and adjustments have been found to be necessary, more time may very easily have been absorbed than would have been had an extra one-half hour been spent in making the impression, and an extra hour spent in balancing the occlusion.

From an economic point of view I contend, and this may need some thought before you would agree with me, that the smaller the fee received for dentures the less you can afford to have your time broken by postinsertion visits for denture adjustments. If you have charged a large fee, you can afford to spend any amount of time in adjustments.

There is still another aspect of this problem. Quite apart from consideration of fees or practice building, there is a personal inner satisfaction in having rendered a satisfactory health service. Adequate remuneration is, of course, very important, and there are no limits to the size of the fee deserved or earned when a really satisfactory service has been rendered; but if you can tell me you have never experienced a real feeling of pleasure in the knowledge that you have enabled some poor edentulous patient to prepare his food efficiently for digestion, and thus increased for him the joy of living—then I say you have missed your vocation and that a commercial pursuit would have provided you with considerably greater opportunities for amassing a bank balance.

Up to this stage I have endeavored to impress you with my belief that the problem of constructing satisfactory functioning dentures is an economic one. While many men say they cannot afford to devote all the time necessary, I firmly believe that if practitioners would devote the necessary time, utilize some degree of skill, apply *all* their knowledge, and spare no pains to see that each and every factor concerned with stability be given full consideration, the majority of dentures would be satisfactory. It does pay to take the necessary trouble.

In the construction of dentures, our objective is to make them conform to the requirements of: esthetics, phonetics, comfort, and masticatory efficiency.

Freely admitting the importance of esthetics and phonetics, I do not propose to discuss those aspects at all. I will deal with one aspect, namely, masticatory efficiency, comfort of course being a necessary factor, for I believe that the main, the most important, necessity as regards artificial dentures is the ability to masticate one's food, since health, and in fact life itself, is dependent upon that function.

I am, of course, quite aware that to many patients appearance is most important, and that many women patients look upon dentists as just another type of beauty specialist. However it should not be difficult to impress upon such patients that all beauty aids fail, that cosmetics are valueless, if through indigestion their noses become red, and their skin loses its smooth texture.

Our test, then, is mandibular stability, and if all the factors concerned with stability are appreciated and applied, successful dentures will usually result. Unfortunately, I see so many mandibular dentures where not only one but several factors have been entirely ignored.

I will not outline any particular technique, for technique is not the main consideration. This article deals with principles, for I am quite sure that equally good results can be obtained with any of several quite different techniques for securing impressions, registrations of jaw relations, or tooth arrangement, and the like. However, while I propose to deal with principles, I wish to do so in a practical manner and not in theory only.

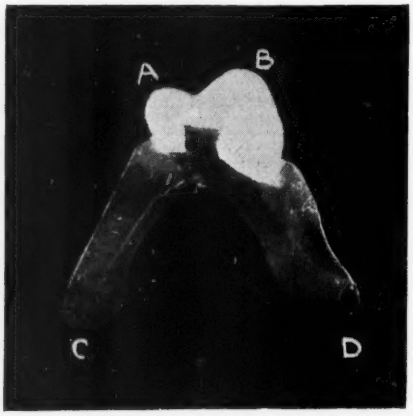


Fig. 1.—*AC* and *BD*, Polished surfaces. *CD*, Impression surface. *AB*, Occlusal surface.

Before dealing with the principles involved, let me say that I realize that some mouths are more difficult to contend with than others, and that preparation of a surgical nature at times is necessary. I cannot understand why it is that so often dental surgeons struggle with conditions about the mouth which complicate and make more difficult the construction of dentures, when some, and frequently some very minor, surgical procedure would simplify the construction of the denture. It is therefore presupposed that, in this article, we are dealing with mouths which are in a suitable condition for the reception of dentures.

Apart too from the question of physical difficulties, it is recognized that the patients' temperaments and mental attitudes have a direct bearing on the prognosis. It is necessary at times to attempt to alter their mental attitudes, to instruct them regarding the difference in the functioning of natural and artificial dentures, and teach them the part they must play in insuring the success of their new restorations. They must be told how and what to eat during the first few days or weeks after insertion. Unquestionably, the success of any denture depends in no small measure upon the intelligent cooperation of the patient.

DENTURE SURFACES

I find it very convenient to utilize the idea evolved by Fish[1] and to consider a denture as exhibiting three surfaces (Fig. 1), the polished, the impression, and the occlusal surface.

The polished surface includes the lingual, labial, and buccal surfaces of the teeth, and the lingual, labial, and buccal surfaces and the periphery of the denture itself. The impression surface is that part of the denture derived from the impression. The occlusal surface is constituted by the portions of the teeth which contact during occlusion.

These surfaces will not be discussed in their order of importance, but in the order which lends itself to a more simple correlation. At the same time it must be understood that it is not possible to confine the discussion of any of these surfaces to a watertight compartment. There will be overlapping, but it will be easier to discuss the individual factors which concern each surface.

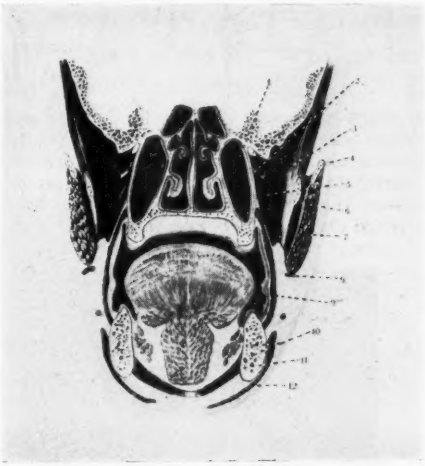


Fig. 2.—A cross-sectional cut through the head but not quite vertical. It shows the potential denture space, and it is obvious that the tongue and buccinator muscle will be in continuous contact with the polished surfaces of the denture in the molar region. (From Schlosser, R. O., Complete Denture Prosthesis, W. B. Saunders Company.)

POLISHED SURFACES

Fig. 2 shows the potential denture space which is the space to be occupied by the dentures. Hanau's[2] definition of denture space is, "That space in the oral cavity which is bordered by the lips anteriorly, the cheeks laterally and the tongue interiorly, the maxillary ridge and the palatal vault above, the mandibular ridge below, the lingual tissue attachment at the borders of the floor of the mouth and the palate, and by the continuation of the oral cavity posteriorly."

It will be seen in Fig. 2 that the polished surfaces are almost entirely in contact with muscular tissues which are constantly on the move. These muscles can readily dislodge a denture which is incorrectly shaped, but they can exert a very definite and strong stabilizing, and in fact retentive, force on the dentures. Yet this large area of surface is not given much consideration by many dentists; in fact, all too frequently the shaping of the dentures is left to the technician, who has little or no idea of the anatomy of the parts.

You are familiar with the fact that, if a force be exerted against an inclined plane, components of force may be resolved in any two directions at right angles to each other (Fig. 3).

So if we shape the mandibular denture so its lingual surfaces look inward and upward, and its buccal surfaces outward and upward, we will have a denture that is triangular in cross section. Consequently any lateral pressure on the denture from tongue and cheeks must tend to force the denture downward against the supporting surface.

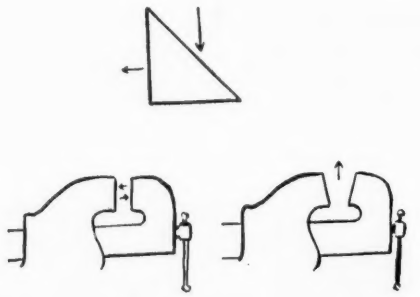


Fig. 3.—Influence of inclined surfaces. Arrows in upper diagram indicate how a vertical pressure on an inclined surface will cause a component of force horizontally so that if a solid body with inclined surface were on a horizontal plane, pressure on the inclined surface would move the body along the horizontal plane. The lower diagram represents a vice; if the jaws were parallel an object between the jaws would be gripped when they were brought together, but if the jaws diverged then the object would tend to slide out.

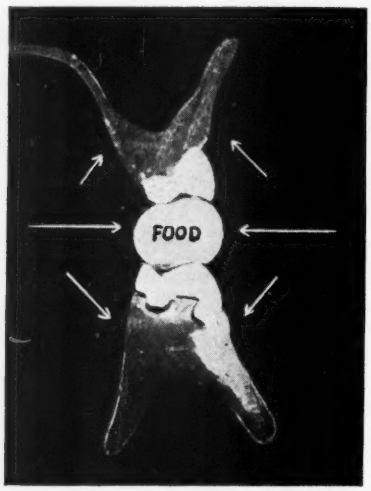


Fig. 4.—Horizontal arrows represent force exerted by the tongue and cheek in holding food between teeth, the inclined arrows represent components of force which tend to seat the dentures in position.

Let us imagine a situation where a round, hard lollipop is to be cracked between the teeth. If there were no auxiliary muscles of mastication to hold the lollipop between the teeth, it would tend to slide out from between the teeth, either into the vestibule or on to the floor of the mouth (Fig. 4). But in fact, when we bite to crack such a type of food, consciously or unconsciously, we do hold it in position between the teeth with the tongue and the cheek. This lateral pressure of the tongue on one side and the cheek on the other will, if the polished surfaces are correctly shaped, exert a component of force upward on the maxillary denture and downward on the mandibular denture, and thus exert a powerful stabilizing force.

To obtain the maximum assistance from the muscles, the buccal flange of the denture from the bicuspid region posteriorly must be extended to the physiologic limits (Fig. 5).

The buccal flange in the bicuspid region must be appreciably narrowed instead of being extended (so must the impression surface and the occlusal surface); otherwise the denture will be dislodged.

An extended buccal flange in the molar region not only enables the development of a buccally inclined surface but provides a surface on which the contracting buccinator muscle can rest and assist in retaining the denture during masticatory effort.

Some practitioners do not appear to think that comparatively large buccal extension can be made in the majority of cases. In practically all cases, however, they can, for even where the ridge has entirely vanished and there is a concavity instead of a ridge, the flange is still practicable (Fig. 6). The functioning of the buccinator muscle upon the buccal flange can be readily appreciated if the action of this muscle is understood.

Fig. 5.

Fig. 6.

Fig. 5.—Typical denture. Buccal flanges extended in the molar regions and narrowed in bicuspid region.

Fig. 6.—Diagram of a transverse section through the first molar region of a mandibular denture and mandible. D+A when the alveolus has been resorbed. *M*, Present shape of the mandible; *A*, part which has resorbed, and *D*, denture as it would have been before resorption took place. (From Fish, E. W., Principles of Full Denture Prosthesis, Staples, Press, Ltd.)

The buccinator muscle has its origin in the pterygomandibular raphe, and on portions of the maxilla and mandible. From this origin the muscle passes anteriorly and is continuous with the orbicularis oris muscle. Its upper fibers are continuous with the lower fibers of the orbicularis oris muscle and its lower fibers with the upper fibers of the orbicularis oris muscle (Fig. 7). If the buccinator and orbicularis oris muscles were the only ones to be reckoned with, every time the buccinator contracted it would pull the corners of the mouth backwards; but there is a series of muscles which cross and intercept the buccinator and orbicularis oris muscles at the angle of the mouth. They are the caninus (which arises from the canine eminence), the zygomaticus arising from the zygoma, and the triangularis which originates from the lower border of the mandible.

All these muscles radiate from the angle of the mouth as the spokes of a wheel radiate from the hub, and the meeting point is termed the modiolus. By contracting, these three muscles can fix the corner of the mouth so the buccinator muscle can contract without appreciably affecting the orbicularis oris or distorting the mouth.

The lower fibers of the buccinator are somewhat flaccid, and it is chiefly the middle fibers which are active in holding food in position during masticatory effort, and which stabilize the dentures. "When the muscles contract to hold food between the teeth, they do not reduce the depth of the sulcus in the molar region as they do in the bicuspid region, they form a pouch in which a piece of food which has been cut off a large bolus can be stored or held while other food is being further triturated."[1] It is because of this comparative flaccidity and pouch formation that the buccal flange of the dentures can be extended to form the inclined flange previously mentioned.

It is the modiolus (Fig. 8) which can readily dislodge a denture if it is not narrow in the bicuspid region, which is close to the angle of the mouth. While I strongly recommend the buccal extension, distal to the bicuspids, to obtain the full benefit of muscular control, it is probably more important to narrow the arch of the teeth and the buccal flange of the denture in the bicuspid region than to extend the buccal flange as recommended.

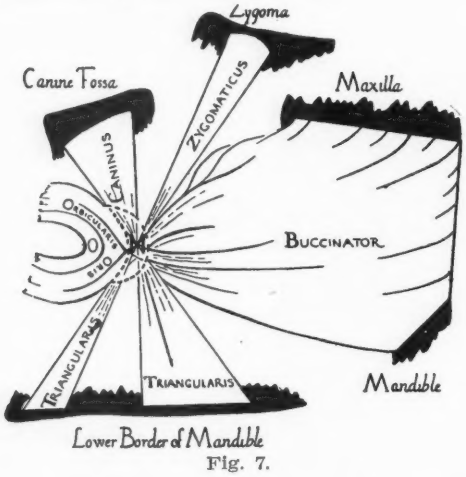


Fig. 7.

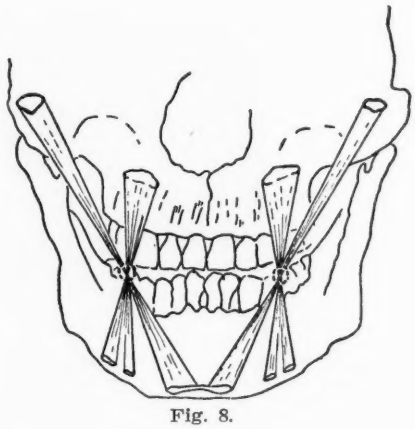


Fig. 8.

Fig. 7.—The modiolus. (From Fish, Principles of Full Denture Prosthesis.)
Fig. 8.—The M. cruciati modioli forming a V-shaped strap which tends to lift a lower denture if it is too wide in the premolar region. (From Fish, Principles of Full Denture Prosthesis.)

In so far as the lingual surface is concerned, it is of great importance that the unruly member, the tongue, should not be permitted to exert any dislodging upward pressure on the denture but that it be utilized to hold the denture in position. It is, therefore, important that this surface should look inward and upward, so that when the tongue exerts a lateral pressure on food it will exert its component of force downward. To accomplish this and at the same time keep the arch and the buccal flange of the denture narrow in the bicuspid region, it may be sometimes necessary to grind from the lingual surfaces of the first bicuspid teeth, and to extend the base material medially over the floor of the mouth. This latter procedure will form a very thick lingual margin and form a definite lingual extension over the floor of the mouth. The extension is horizontal at the base, and by its width it enables the inclined surface to look inward and upward so the tongue can exert its downward component of force on the denture while food is being triturated.

A common mistake is to make the lingual surface of the lower denture concave instead of permitting every portion of the lingual surface to look upward and inward. A concavity will cause a portion of that surface to look downward instead of upward, while a concavity may give tongue room, but when the tongue moves upward it can dislodge the denture.

The periphery, or the denture margins, form part of the polished surfaces, and it is of great importance that all margins be rounded and well polished so that the soft tissues may move about the margins without irritation or pain.

I cannot agree with some advocates[3, 4] of the mucostatic type of impressions who claim that the denture margins should be short and sharp. In the case of a flat ridgeless mandible, such edges could not be tolerated. But quite apart from this aspect, short, sharp edges would not permit the denture to be shaped so that it would be triangular in cross section which is so necessary for muscular control.

Unquestionably the shape of the polished surfaces of any denture can have a most marked effect upon stability, and can enable the patient with very little experience or practice with the denture to exert a definite and powerful control. Muscular control is a very important factor in denture retention and stability.

You have all seen patients who have worn dentures for many years and who tell you they can eat an apple and other types of food quite well; yet on examination it is seen that the dentures do not fit because of absorption; and the occlusion is not balanced. What has happened, of course, is that over the period of years the patient has unconsciously trained his or her muscles to hold the dentures in place. Do not forget, however, that this long training of the muscles can be a menace. While over the period of years the patient has no doubt gained a control over the dentures, those same trained muscles will resent any great change being made when new dentures are constructed. New dentures of correct shape and made with greater distances between the occlusal and impression surfaces to occupy the now increased available denture space will be frequently most uncomfortable to wear.

If the first dentures a patient wears are properly shaped, the patient can, without any long period of training, hold the dentures in place because the normal contraction of the buccinator muscle, plus the action of the tongue in holding food in place, will assist in stabilizing the denture.

IMPRESSION SURFACE

I think the impression surface has the least effect on the stability of a denture, and the technique of securing an impression is relatively unimportant. Of course a good impression is necessary, but I am very strongly of the opinion that the securing of a good impression does not mean a successful denture.

The following is a quotation from an article by Riddell and Davidson[5]: "The object of this technique is to produce a retentive lower denture regardless of whether the ridge is good or bad or absent: a lower denture that will resist displacement by any normal muscular movement of the jaw, or upon placing an instrument between any of the teeth and pushing it, unless an excess upward force is used." To my mind, this is absolutely ridiculous, for no matter how good the

impression, nor by what technique it is taken, if there be undue leverage on the denture or if there be cusp interference, or the polished surfaces be so shaped that muscular action can exert a disruptive force, the denture will be dislodged.

Ante[6] states (and with this I agree), "In successful denture practice esthetics, exact centric relation and balanced occlusion all outrank the impression in importance, but a good impression is nevertheless an important step in denture construction."

Gillis[7] states, "No system of impression making can succeed unless good articulation is established. No patient ever presents himself with soft flabby ridges unless he has worn dentures that are poorly articulated."

In my opinion one of the most important factors concerned with the impression surface is that the maximum tissue area be covered. This is important for several reasons:

(1) It makes maximum use of any retentive force whether such be surface tension, adhesion, or atmospheric pressure. (2) It distributes the load of mastication over the maximum surface. (3) It enables the polished surfaces to be shaped to give maximum muscular control.

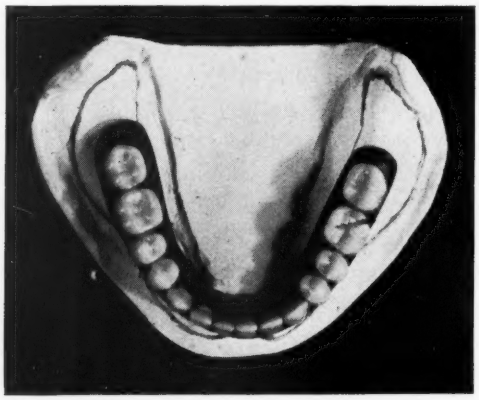


Fig. 9.—An underextended denture and the correct denture outline on a cast.

Fig. 9 shows a denture typical of many that come under my notice. The occlusion was bad, but, quite apart from that aspect, it is obvious that there would have been much greater stability had the denture covered the available area as marked on the cast.

I am not discussing technique, but I want to controvert some of the statements made in dental journals by advocates of the mucostatic impression methods. They make two claims with which I am in total disagreement: first, that there is no need to cover a large area[8] and, second, that the margins of the denture should be made razor sharp.[3, 4]

I believe that there are many techniques which will give equally good results, but I am sure that dentures covering small areas and not utilizing a great deal of available area will not permit the maximum stability of the denture to be obtained, no matter how good the retention. The load of masticatory force is confined to an unreasonably small area, and it is not possible to shape the dentures to give full muscular control since such dentures do not, and cannot, provide buccal flanges.

One writer[8] states that there is no need for any depth of flange except to prevent lateral movement of the denture, and he compares it with the flange of a railway wheel (Fig. 10) where the flange is necessary only to keep the wheel on the rail. He illustrates the mandibular denture with a very short lingual flange in the molar region and practically no buccal flange. This is somewhat ridiculous, for what would be the result if such a denture were made for a very narrow ridge? Think of the pressure on that narrow ridge, and the impossibility of developing a buccal flange!

What particularly annoys me with advocates of this type of impression is that some of them appear to draw diagrams to suit their arguments, and at times misrepresent conditions. Fig. 11 is one example, and surely no one has seen a section of a mandible in the molar region look like that. The whole width of the mandible from the mylohyoid ridge to the external oblique ridge is just the width of the molar tooth and that is rather extraordinary. The distance the denture flanges extend below the ridges also equals the distance between these ridges. It would be impossible to extend the buccal flange in any mouth so far below the external oblique ridge. A diagram such as this misrepresents conditions to bolster an argument.

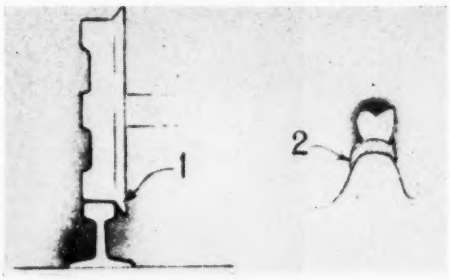


Fig. 10.

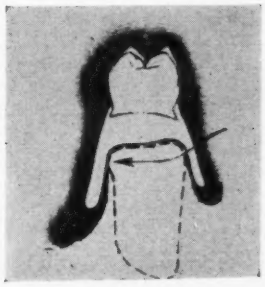


Fig. 11.

Fig. 10.—Flanges beyond the bone width prevent lateral movement of dentures. *1,* Car wheel flange. *2,* Lingual extension. (From Dykins, W. R., Tic, March, 1949.)

Fig. 11.—A diagram with denture, tooth, and mandible entirely disproportionate. The original legend read, "Cross section of mandible and denture showing unnecessary extension of flange below the mylohyoid ridge." (From Dykins, Tic.)

Figs. 12 and 13 illustrate the available area which should be included irrespective of the impression technique. In making such an outline on a cast (made from an overextended primary impression) when a baseplate is to be made for taking the final impression as in Terrell's technique,[9] or when a tray preparation is used,[10] the procedures would be as follows:

The buccal outline is commenced by including the distal end of the retromolar pad and making the line proceed along the buccal very close to the retromolar pad till the apex of the triangle is reached, for in this region the cheek is closely attached. The line would then swing outward, even over the external oblique ridge, to form the buccal extension, for it is quite possible for the buccal extension to rest on some of the lower fibers of the buccinator. It would then narrow in the bicuspid region to be free of the action of the modiolus, then widen out again but narrow in for the labial frenum.

On the lingual, the line can dip down to form a semicircle below the retromolar pad, coming up to meet the beginning of the mylohyoid ridge (Fig. 13). The line then would proceed along the crest of the mylohyoid ridge till it reaches its greatest distance below the crest of the alveolar ridge in the bicuspid region, from which point the line proceeds upward to avoid the sublingual gland. It then narrows to accommodate the lingual frenum. Some practitioners advocate extending the lingual flange varying distances below the mylohyoid ridge, but in general I do not think it advisable or necessary.

Before leaving the consideration of this surface, I would say that as regards the mandibular impression, it does not matter what technique you use, nor whether your material be modeling compound, plaster of Paris, one of the hydrocolloids, or a material such as Mucoseal, nor whether you use controlled pressure or no pressure, provided your technique permits you to utilize the whole available area, and that you obtain a reasonably accurate surface fit to the tissues.

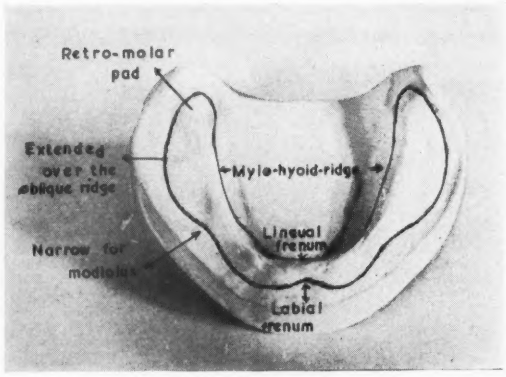


Fig. 12.—The denture outline.

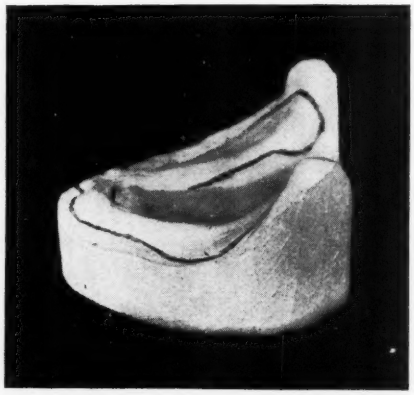


Fig. 13—The lingual outline for denture.

OCCLUSAL SURFACE

Of the three surfaces of the denture, I consider the occlusal surface to be the most important. I have pointed out that the impression surface plays a part in obtaining stability, and that the polished surface does so to perhaps a greater degree. In one sense, however, it may be said that the occlusal surface does not play an *active* part in the provision of stability, but it can be, and frequently is, an unstabilizer.[1]

This surface is the working surface of the denture, and no matter how strong the retention developed, nor how well shaped the polished surfaces may be, cuspal interference associated with unbalanced articulation can unstabilize the denture. Whether or not it causes actual dislodgement, it certainly will cause tissue trauma, which in turn may lead to ulceration in localized areas, and may cause uneven and undue resorption of the alveolar ridge.

Quite apart from the unstabilizing effect of unbalanced articulation, undue leverage associated with the absence of unilateral balance can very effectively un-

stabilize a mandibular denture when food is being crushed on one side. In fact, unilateral balance is perhaps just as important as balanced articulation or bilateral balance, or as it is sometimes termed "three point contact." This is because a patient can be trained, or he may accustom himself to eat with an up-and-down or chopping motion, and so function without bilateral balance. For this type of mastication, however, unilateral balance is a definite necessity.

The following are the main factors relating to the occlusal surface, all of which must be given serious consideration if the degree of stability and retention developed by impression making and the shaping of the polished surfaces are to be maintained:

1. The establishment, with a reasonable degree of accuracy, of the functional vertical dimension of the face which will enable us to establish the vertical dimension of the denture space.
2. The registration of the correct centric relation of the jaws.
3. The provision of unilateral balance which is necessary to maintain stability when the presence of food between the teeth prevents a bilateral balance of the occlusal surfaces.
4. The provision of bilateral balance, that is, balanced articulation with a complete absence of cuspal interference.
5. Spot-grinding and milling on the articulator subsequent to fabrication, irrespective of the type of articulator used and whether or not a three-point contact form of articulation is provided.
6. The possible use of carborundum paste for occlusion or articulation adjustment in the mouth subsequent to insertion.
7. The maintenance of balance by checking and possible adjustment at least once in every six months.

ESTABLISHMENT OF VERTICAL DIMENSION

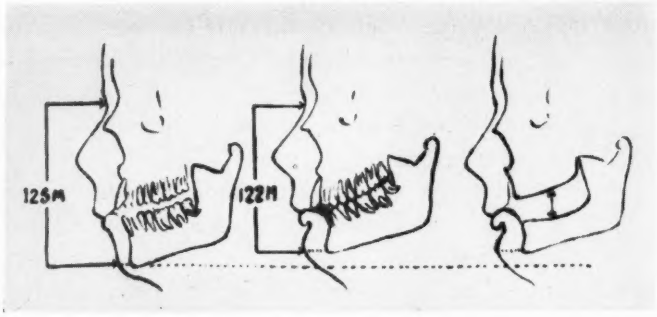
I think we now have a better understanding of the importance of vertical dimension from the functional, esthetic, and comfort points of view. However, the term vertical dimension is frequently very loosely applied for there are actually three vertical dimensions in which we are interested. Yet at times the term is used without qualification as to which dimension reference is being made. When we speak of vertical dimension we should make our meaning clear and indicate to which of these dimensions we are actually referring. There is the true vertical dimension of the face, the functional vertical dimension of the face, and the vertical dimension of the denture space (Fig. 14).

From the functional viewpoint, we are most interested in the vertical dimension of the denture space, that is, the vertical distance between the mandibular and maxillary alveolar ridges, when the mandible is in its functional relationship to the maxilla.

The true vertical dimension of the face, or the true facial vertical dimension, is the length or vertical height of the face when the mandible is in its rest relationship to the maxilla. The rest relationship of the mandible is the relationship in which all the tissues and muscles are relaxed to an extent counteracting the force

of gravity only, when the head is upright, or when the mandible is suspended by the reciprocal coordination of the muscles of mastication and the depressor muscles. When in this relationship, the lips are lightly contacting and the masticating surfaces of the teeth are separated by a space of two to three millimeters. It is the most comfortable position of the mandible, and it is a nonfunctional position; all other positions are functional. It is the position the mandible always assumes after swallowing or clenching the teeth for any other reason; in fact, all functional movements commence from and terminate at this rest position.

The rest position of the mandible is determined by the musculature and not by the teeth; it is established before the teeth arrive, and, while muscles may lose tone or vary in activity, they do not lose length. Therefore, the rest relationship remains constant throughout life.[11, 12] The rest position of the mandible is a most valuable landmark in the establishment of the vertical dimension of the face.



A. *B.* *C.*

Fig. 14.—*A*, True vertical dimension of face. Mandible in rest relationship, lips lightly contacting, teeth not in contact.

B, Functional vertical dimension of face. Mandible in a functional relationship, teeth contacting, lips more tightly contacting. Dimension 3 mm. less than in *A*.

C. Vertical dimension of denture space. This represents the distance between the alveolar ridges when the mandible is in its functional relationship to the maxilla, in which case the interridge distance is 3 mm. less than it would be if the mandible were in its rest relationship. The record of centric relation of the jaws must be secured with this distance maintained.

When the teeth are in occlusion, the vertical dimension of the face is less than when the mandible was in its rest relationship, because the space that was present between the teeth when the mandible was in its rest relationship has been closed by the mandible's upward movement to make contact between the teeth. So the vertical dimension of the face must have altered and lessened, and this lesser vertical dimension is termed the "functional vertical dimension of the face."

The difference in these two vertical dimensions of the face is, of course, dependent upon the magnitude of the space which existed between the teeth when the mandible was in its rest relationship. The space is termed the "free-way space" and, while it varies in different people, it is on the average two to three millimeters.

When the mandible of an endentulous patient is in its functional position, the alveolar ridges will be the correct distance apart for the dentures in occlusion. When the mandible assumes its rest relationship, the teeth will separate to form the free-way space which is most important for comfort, stability, and esthetics. If, therefore, we can establish the rest position of the mandible, we can measure the true vertical dimension of the face; from this we can determine the functional

vertical dimension which will be two to three millimeters less. We know that when the face has assumed its functional dimension, the vertical dimension of the denture space will be correct. If we adjust the height of the occlusion rims so that they contact while the functional position of the mandible is maintained, these occlusion rims will constitute a record of the vertical dimension of the denture space.

It is of the utmost importance that the registration of centric relationship of the jaws be made with this vertical dimension of the denture space maintained, and that this dimension be not altered during the construction of the dentures. The true vertical dimension of the face should be measured first, and this can be done in several ways. A convenient method is to use a pair of calipers to measure the distance from some mark on the upper part of the face such as at the nasion, or the anterior nasal spine, and some selected spot or line marked on the chin (Fig. 15).

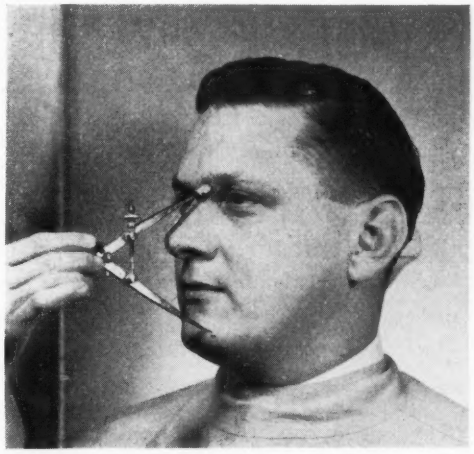


Fig. 15.—Measuring true facial vertical dimension.

A patient can be made to assume his rest relationship in several ways. A simple way is to have marks made on the face for reference points and to ask the patient to say "1, 2, 3, K, L, M," several times, and to instruct the patient to remain quiescent after completing the "M" sound. A caliper measurement is then made between the two marks. An additional mark is made on the chin two or three millimeters lower down than the first mark. When the patient closes his jaws until the calipers reach from the mark on the upper part of the face to the lower of the two marks on the chin, the functional vertical dimension will have been measured.

These marks on the face and the caliper measurement are retained. The baseplates and occlusion rims are inserted into the mouth, and the height of the occlusion rims is adjusted until the caliper points will reach from the mark on the upper part of the face to the lower mark on the chin. When this is accomplished, the vertical dimension of the denture space is registered and recorded by our occlusion rims, and the calipers and marks on the face will have completed their function. This dimension must be retained during the whole construction period

of the denture. When the teeth are set up to this dimension, provision will have been made for two to three millimeters of free-way space.

If the teeth are set up to the vertical dimension of the denture space which would exist when the mandible is in its rest relationship, there will be little or no effect on the patient's appearance. There would be no free-way space and the teeth would contact during rest which will cause muscular strain, chattering of teeth, and possibly a resorption of the ridges. It definitely would cause a loss of muscular efficiency.

If the teeth are set with a vertical dimension of the denture space greater than that which would exist if the space was measured with the mandible in its rest relation, the patient's appearance would be affected. There would be a stretching of the muscles with a strained look about the mouth, and an increased tendency for clacking of the teeth, and an undue leverage which might exert an unstabilizing effect on the denture. There will be also an increased loss of muscular efficiency.

There is a critical distance between the origin and insertion of muscles at which they can exert their maximum power during contraction. When extended beyond this critical distance they lose power.[11] If the vertical dimension of the denture space is less than necessary (with too great a free-way space), the muscular efficiency would be lessened with a probable loss of muscle tone, and there would be an adverse effect on the patient's appearance.

Finally, when the mandible is in its rest position the condyles are in their retruded position, and the closure from rest to the functional position is a simple hingelike movement.[13, 14] A record of centric relation of the jaws is more easily obtained if the jaws are the correct distance apart, that is, when the mandible is in its functional position which is three millimeters less than the true vertical dimension of the face. A centric relationship of the mandible to the maxilla *can* be obtained with the mandible either above or below its normal rest position.

REGISTRATION OF CENTRIC RELATION

It must be recognized that for each and every vertical position the mandible may occupy in relation to the maxilla, there is a definite and separate centric relation, and that, of all the factors concerned with the comfort and stability of dentures, no other one is of greater importance.

PROVISION OF UNILATERAL BALANCE

I do wish to stress the importance of unilateral balance. It is quite obvious that when there is food between the teeth on one side of the mouth, there can be no contact of the teeth on the opposite side; therefore, balanced articulation is not possible until the food has been at least partially crushed. If unilateral balance be not established, leverage will probably dislodge the mandibular denture. If balanced articulation, or bilateral balance, be not provided for in a set of dentures, the patient may be able to accommodate himself to chewing with an up-and-down or chopping motion. But if unilateral balance be not established, even this chopping motion will not be satisfactory, and for this reason I feel that unilateral balance is so very important.

The main factors concerned with unilateral balance are: (1) Teeth of suitable buccolingual width. (2) The setting of the teeth over the center of the ridges. (3) The parallelism between the occlusal plane and the mandibular ridge. (4) The occlusal surface of the teeth placed as close to the mandibular ridge as circumstances will permit. (5) The provision of maximum tissue coverage by the denture.

1. It appears advisable, in many cases, that the buccolingual width of the posterior teeth should be less than that of the natural teeth. By using narrower teeth, the load on the alveolar ridge is lessened, and it is easier to place the teeth over the center of the ridge without encroaching on the tongue space; it is easier to maintain the lingual polished surface so it looks upward and inward (Fig. 16).

Fig. 16.

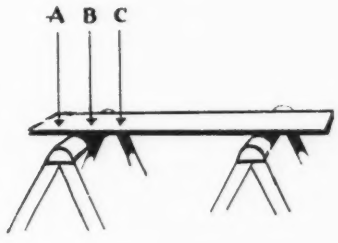


Fig. 17.

Fig. 16.—Suggested width of artificial teeth as compared with natural ones. (After MacMillan, H. W., The Mechanics of Balance, London, 1946, Dental Magazine and Oral Topics.)

Fig. 17.—This illustration represents a board laid across two sawhorses and is analogous to a mandibular denture. Force applied at *A* would tend to cause the board to lift from the horse on the right side, the sawhorse on the left acting as the fulcrum of a lever of the first class. Force acting at *B* would not tend to cause any lifting from the horse on the left but all the force would be received by the horse at the left. Force acting at *C* would not tend to cause movement in the board but the force would in part be received by the horse on the right. (From Sears, V. H., Principles and Techniques for Complete Denture Construction, The C. V. Mosby Company.)

2. If the posterior teeth were placed inside or lingual to the ridge, no amount of vertical pressure could dislodge the denture; but if the posterior teeth were placed outside the ridge, the ridge would act as a fulcrum of the first class lever so that, when the food was being crushed on the one side, the opposite side of the denture could be levered from its supporting surface (Fig. 17).

3. It is advisable, where possible, to have the forces of mastication directed at right angles to that portion of the mandibular ridge best able to resist such forces, that is, the bicuspid-first molar region.[15, 16] To effect this, the occlusal plane should be made parallel to this portion of the ridge. If the maxillary and mandibular ridges are parallel, and the occlusal plane is made parallel to both ridges, and particularly if flat plane teeth are used, then all masticatory forces would be directed at right angles to both ridges, and both dentures would be stable in so far as this particular requirement is concerned (Fig. 18). If the ridges are not parallel and the occlusal plane were made parallel to the maxillary ridge, the maxillary denture would be stable, and the mandibular one would tend to be forced anteriorly from position. If in this case the occlusal plane were made parallel to the mandibular ridge, the mandibular denture would be stable and the maxillary denture would

tend to be forced anteriorly; however, this denture, having better retention, would in ordinary circumstances resist this tendency. If the occlusal plane were not parallel with either ridge, both dentures would tend to be dislodged. The alveolar ridges act as inclined planes when they are not parallel.

To make the forces of mastication be directed at right angles to the ridge is easy to accomplish with nonanatomic teeth, but with anatomic teeth, as they are ordinarily set up, the cusp inclines will, if a protrusive movement be made, have components of force directed anteriorly in the maxillary denture and posteriorly in the mandibular denture. Whatever type of tooth is used, it still appears advisable to make the occlusal plane parallel with the mandibular ridge.

4. Even with the teeth set over the center of the ridge, if the occlusal plane is any considerable distance above the alveolar ridge, there may be sufficient leverage to interfere with stability. Fig. 19 illustrates that the greater the distance between the occlusal plane and the ridge, the greater the leverage when anatomic teeth are used. It is a case of component of force when an inclined plane is opposed by another inclined plane.

5. It must be quite obvious that the greater the area covered by the denture the more stable the denture will be when forces act.

Fig. 18.

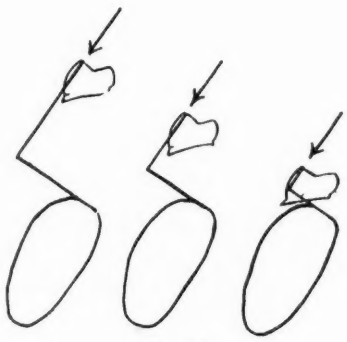


Fig. 19.

Fig. 18.—In these diagrams the upper line represents the maxillary ridge and the line between it and mandible represents the occlusal plane. For mandibular stability the occlusal plane should be parallel with the mandibular ridge (in the bicuspid-first molar region).

Fig. 19.—Increased leverage as teeth are placed farther from the ridge. (After Swenson. M. G., Complete Dentures, The C. V. Mosby Company.)

BILATERAL BALANCE OR BALANCED ARTICULATION

Balanced articulation is well understood, and those who use adjustable articulators in the endeavor to provide for balance are quite familiar with what is expected. With the use of cusp teeth, balanced articulation is most difficult to obtain without the use of a fully adjustable articulator, and without this balance maximum stability of the mandibular denture cannot be obtained. If such an articulator is not used, the two suggestions I would make are: make sure of unilateral balance and endeavor to train your patient to practice mastication with a simple up-and-down motion.

If you use cusp teeth without an adjustable articulator, you should use a cheaper form of tooth, that is, a tooth with flatter cusps or possibly teeth of acrylic

resin. Acrylic teeth admittedly wear with use, and changes in vertical dimension are more rapid because the teeth lose height by wear. However, trauma is lessened, and as the wear takes place balance and stability tend to improve even if the life of the denture is shortened.

Finally, I think that if you do not use an adjustable articulator, you will get better results by using nonanatomic teeth.

PASTE GRINDING AND MILLING-IN ON THE ARTICULATOR

Whether or not balanced articulation is attempted, it is of the greatest importance that grinding-in of the occlusion be carried out subsequent to the fabrication of a denture. No matter how carefully the teeth are occluded on the articulator, dimensional changes (whether the denture be of vulcanite or acrylic resin) will take place during fabrication, and grinding-in is necessary to correct any change in the position of a tooth or teeth. If anatomic or balanced articulation be not provided, it is essential that when the patient occludes in centric position there will be a close and even contact of all the teeth. A Dox grinder is a very valuable adjunct in such cases.

POSSIBLE USE OF CARBORUNDUM PASTE SUBSEQUENT TO INSERTION

In a number of cases, irrespective of the care in setting up and grinding-in on the articulator, the use of carborundum paste in the mouth will improve the articulation.

MAINTENANCE OF BALANCE BY PERIODICAL CHECKING

It is fully recognized that dentures will not retain their balance over a long period of years. Resorption of the ridges takes place with the loss of supporting tissues, and the jaws must move closer together to contact. Consequently, the mandible must assume a more protrusive relationship, so centric occlusion will no longer be accurate. Grinding-in is necessary from time to time if balance with freedom from cusp interference is to be maintained.

If all the factors concerned with the development of the three denture surfaces are given due consideration, the problem of the mandibular denture as part of a full set of dentures will be, if not entirely eliminated, at least very considerably reduced. However, there are quite a lot of factors. Unfortunately so many dentures which are failures give evidence that not one, but several, of the factors have been disregarded. In such cases failure is not due to the denture being a specific problem but due to a lack of care on the part of the practitioner. It is for the most part an economic and not a technical problem.

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CENTURY OF STANDARD MAXILLARY AND MANDIBULAR IMPRESSIONS WITH REFINEMENTS

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MANY dentists are amused as well as surprised, after reading a description of a lengthy impression technique, to note that the author, in conclusion, suggests "that an authorative technique be announced and adopted." Such a statement reflects doubt in the reader's mind as to the merits of the technique, and makes him wonder if it is just the author's enthusiasm for his impression technique per se.

"Where does muscle trimming begin and where does it end?" This question also seems controversial in dentistry. However, patients, especially women, deem it silly or unnecessary, and they are correct. Elderly people cannot and will not cooperate very much due to a lack of tissue resiliency and general fatigue. Muscular or facial distortion will not change the outline of a maxillary denture flange in the region of the tuberosities, and will change it little in the molar region, but the area between the bicuspids *can* be trimmed to the end near the incisive papilla, especially if the patient has a soft upper ridge. So it is very obvious that the answer to where muscle trimming begins and where it ends is: there is no beginning if the impression material does not distend the soft tissue, and the ending would be the limit to which the distended tissue could be reduced. Therefore, the final answer is that muscle trimming is not indicated, necessary, or desirable at any time in the outlining of a maxillary or mandibular impression.

The most difficult, if not impossible, technique is one that endeavors to generate outline form and favorable tissue detail in the impression simultaneously with an impression material that lends itself readily to muscle trimming by heating or whittling, or by one that possesses elastic tendencies. The operator should soon realize that if and when outline form is obtained, tissue detail is most certainly lost. Tissue detail is more important for comfort and stability than outline form. In fact, some prosthodontists insist that underextension is preferable to overextension. However, most all agree that tissue detail, without derangement, is the ideal objective.

For nearly a century, dentistry has used the same standard impression technique very successfully. Although new materials and techniques have been accepted, not one has proved as reliable or practical as the straight plaster of Paris technique of our forefathers (Fig. 1).

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The subject of impressions has been a highly controversial one, and, unusual as it may seem, could still be the subject for a very interesting and scientific moot. The proper approach to such a study should be from the standpoint of the resilient soft tissue. It should not be from the standpoint of myology or osteology, nor of the merits of a technique to promote another impression ma-

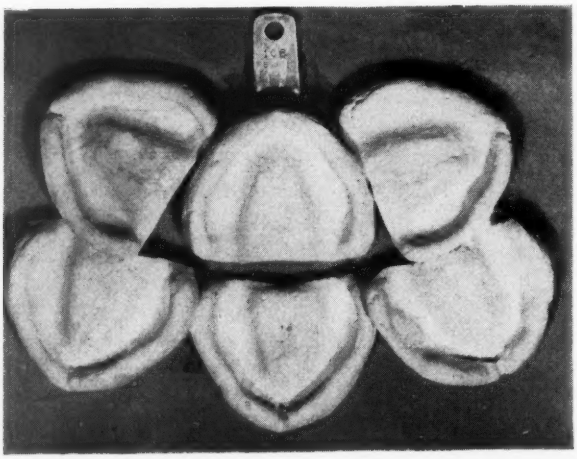
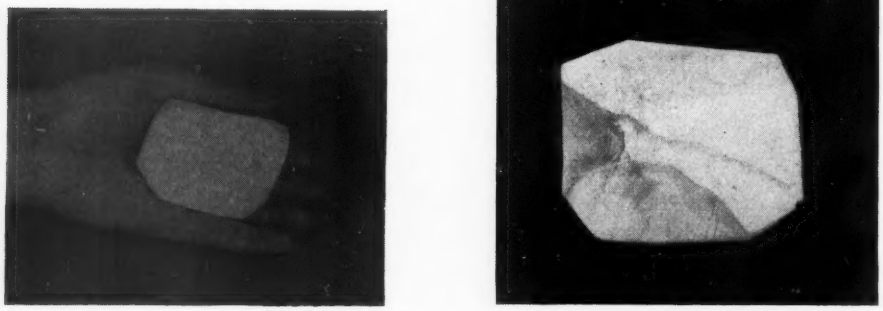


Fig. 1.—A cluster of six plaster maxillary impressions, made at different sittings, with Kerr's Snow White No. 2 plaster. The time was five minutes and the cost about five cents per impression. Dentures made over casts from such impressions have unusual adhesion, need no relining or rebasing, and very little rim-trimming.



A. *B.*

Fig. 2.—Plaster impression and cast of a palm. The impression shows a minimum of tissue derangement and excellent fine-line detail.

terial. Believing in a technique or impression material is not very practical nor scientific, so it could be placed in the realm of politics or religion. But a one-minute ocular and digital examination of a partially cupped hand will quickly remove or clarify the mystery, since the palm and fingers of the hand simulate the tissues of the oral cavity. Most believers or followers of complicated impres-

sion techniques lose at least some of their enthusiasm and confidence when asked to reproduce the tissue detail of a palm without derangement or distortion (Fig. 2).

If greater stability is obtained without pathologic changes in the supporting tissues, one of the greatest advances in prosthesis has been achieved by developing the mandibular and maxillary denture into a physiologic appliance. Too many impression techniques have been based upon the anatomy of dry maxillary bones.

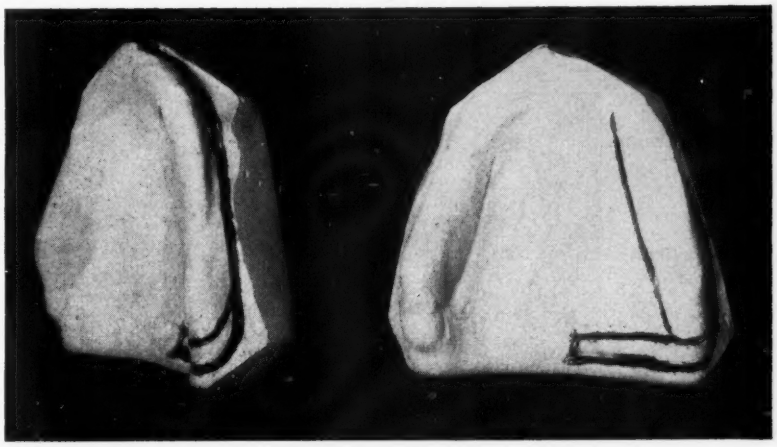


Fig. 3.—Master cast. Technique of outlining with pencil the peripheral retention beading and postvalve seal.

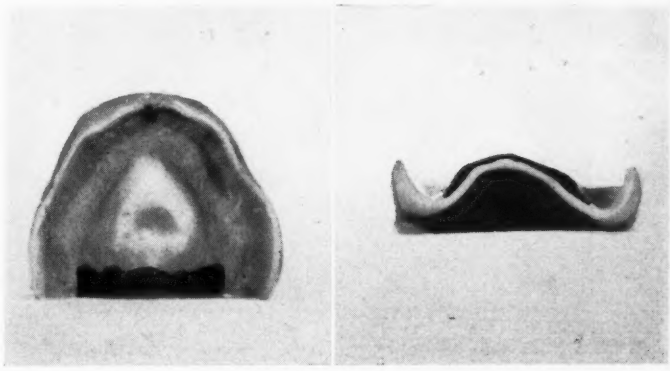


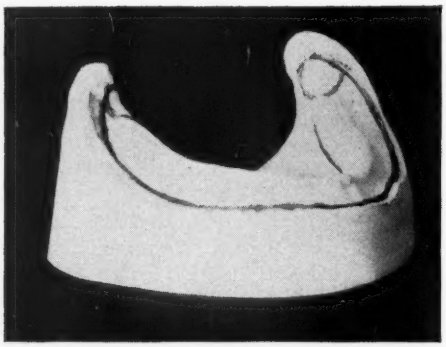
Fig. 4.—The wax postpalatal seal. The thickness of wax determines the palatal outline and the depth of displaceable tissue for adequate retention. When reproduced on the master cast, the seal materially increases the retention and stops gagging.

Stereotyped dissections of prepared specimens, such as are usually found in the anatomic laboratories, are of only slightly more value.

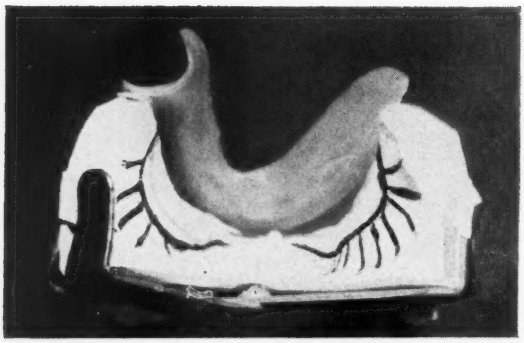
It is interesting to contemplate that the normal relations of the parts inside the mouth proper cannot be observed in the patient by the examiner. As soon as the mouth is opened, the parts are put on tension, muscles have come into play, and everything contained within the mouth assumes a relationship far different

from that of the same structures at rest or during functional excursions. These abnormal relationships are too often obtained in making impressions. The resulting prostheses are constructed over casts that do not portray the relationships of rest or of function or the happy medium.

Any impression material that forces the mylohyoid muscle and sublingual tissues to follow the contour of the mandible inferiorly to the mylohyoid ridge is ill advised, because a denture made from such an impression would traumatize the tissues or be elevated from its base every time the mouth was opened. Any



A.



B.

Fig. 5.—Master cast outlined and beaded for retention. The denture is finished at the beaded outline. This eliminates the necessity for boxing the impression.

impression technique that will derange soft tissues violates the principle of denture retention or comfort known as hydrostatics and Pascal's law. Therefore, it is obvious that a proper technique for developing a mandibular or maxillary denture into a physiologic appliance should be one that manipulates a surplus of soft impression material to contact, flow, and set with a minimum of abnormal relationships or derangement of soft tissue. Additional retention may be obtained by beading the cast and an accurate postpalatal seal (Figs. 3, 4, and 5).

One indisputable fact still remains. The century-old plaster technique has no need or indications for washes, relining, rebasing, or other so-called modern methods, as dentures processed on casts from such impressions can be worn with comfort and stability for years. The writer has not relined or rebased a denture in nearly twenty years. He never did use the primary and secondary wash technique which seems so popular today.

Patients confess that the relined denture was not any better, or that it was so only for a short time when it again started to drop. A report on the mandibular denture reline is generally not even that encouraging. The lining procedure certainly creates a temporary fit with a continuous chain of line and reline until the unhappy ending.

Relining or rebasing fails to correct a temporary fit, because the derangement of the soft palatal tissue by trapped air and lining material, and the repositioning of the lined denture downward or forward increases the unfavorable anterior thrust of the posterior teeth.

Reprocessing the old denture on a cast from a new impression has proved more accurate and reliable than rebasing or relining. The soft tissues are not deranged nor is the denture repositioned down and forward. There is no violation of the dictates of directional force, and very slight change in the centric relation or occlusion. In reprocessing a maxillary denture on a cast from a new impression, the retention is maintained by peripheral beading and a new postpalatal seal. The wax pattern is generated on the denture and duplicated on the cast before the denture is processed.

The announcement: "What America needs is a good five-cent cigar" created considerable interest, but the suggestion that "What dentists really need is to learn how to take or make a good plaster impression" will, in all probabilities, be unheeded.

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A METHOD TO CHECK POSITIONAL RELATIONS ON THE ARTICULATOR

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CLAIMS and counter claims are rampant for the various restorative and prosthetic techniques, in respect to their ability to reproduce positional relations from the mouth to the articulator. Many of the methods used to demonstrate the adaptability of these instruments are not scientific, and are valueless in their ability to prove anything. It is regrettable that some of these men, who are the proponents of the various theories of occlusion, have not heard of the Needles' split cast method for checking positional relations on the articulator, or if they do know about this method, do not use it.

Years back, when the various articulator theories were first propounded, and acrimony and feelings ran high in relation to these individual techniques, there was no scientific method to check their claims until Needles devised his technique. Until that time, arbitrary check bites to test positional relation were usually made in wax, and positioned on the lower cast on the articulator. The upper member of the articulator would then be moved, with apparent position, into the wax check bite (Fig. 1). Needles saw that by this method discrepancies could develop, as it would be impossible to see whether or not the wax bites were correctly positioned on the occlusal surfaces of the upper teeth. To overcome this defect Needles devised the split cast method.[1]

Briefly, the Needles split cast technique was as follows: the base of the maxillary cast is keyed by the cutting of three notches in it. Both the maxillary and mandibular casts are attached to their respective members of the articulator with a separating medium being placed between the maxillary cast and its luting plaster. The articulator is then set to follow the method suggested by its manufacturer. A checkbite of compound, wax or plaster which records a positional jaw relation is carefully obtained from the patient. The checkbite is then placed on the occlusal surfaces of the teeth of the lower cast, and the detached maxillary cast is placed into its correct occlusal position. After the casts are securely waxed to the positional relation, the upper member of the articulator is moved to a position above the base of the maxillary cast. If the index of the luting plaster does not fit into the keyed cast, the articulator did not check the relationship obtained from the patient; and conversely, if the index and the keyed cast did fit accurately, the articulator did check in this position.

We have been using a modification of Needles' technique, in those cases where the maxillary cast was not previously prepared, by keying the casts before

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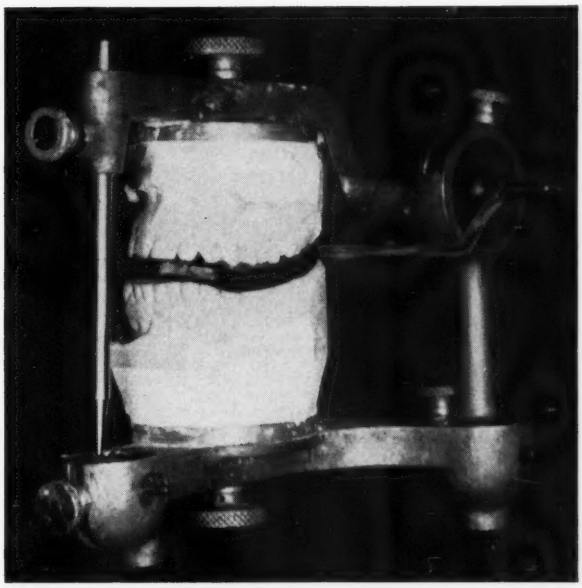

Fig. 1.—An unscientific method of checking a patient's positional jaw relation on the articulator. It is impossible to ascertain whether or not the upper teeth fit accurately into the occlusal record.

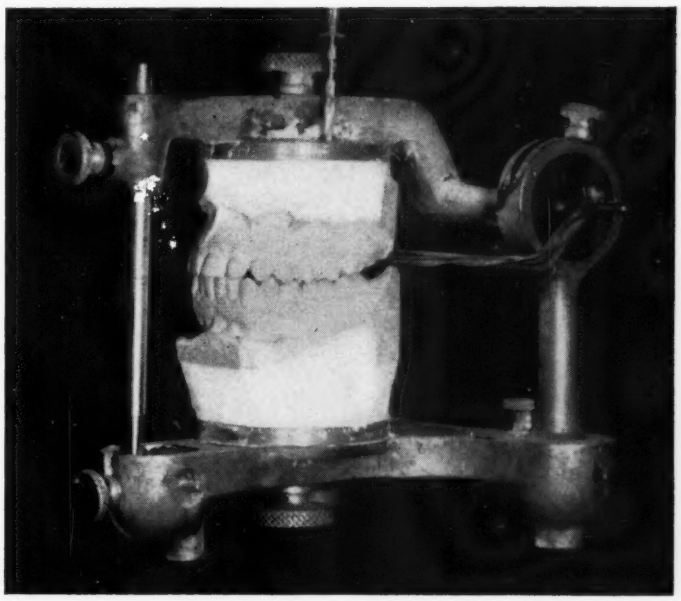

Fig. 2—A No. 42 carbon steel drill held in a dental handpiece to drill holes at various angles through the luting plaster into the maxillary cast. A number 9 round bur can also be used for this purpose.

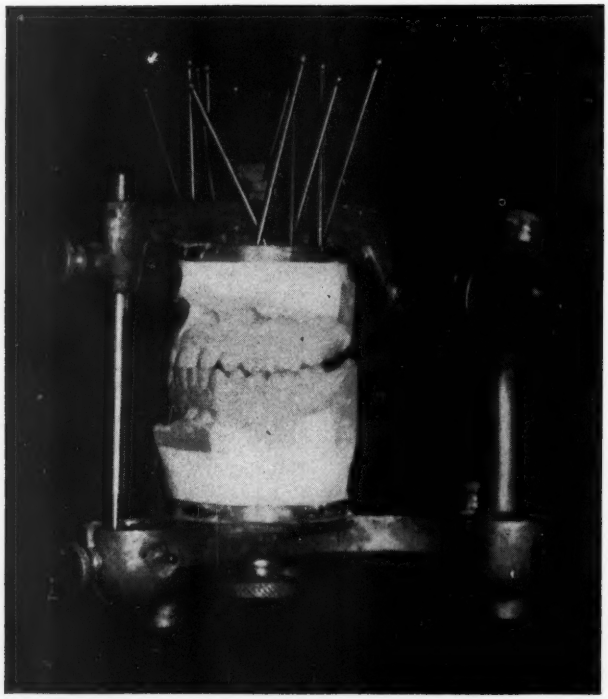

Fig. 3—Finishing nails or burs can be used to act as positioning rods between the plaster and the cast.

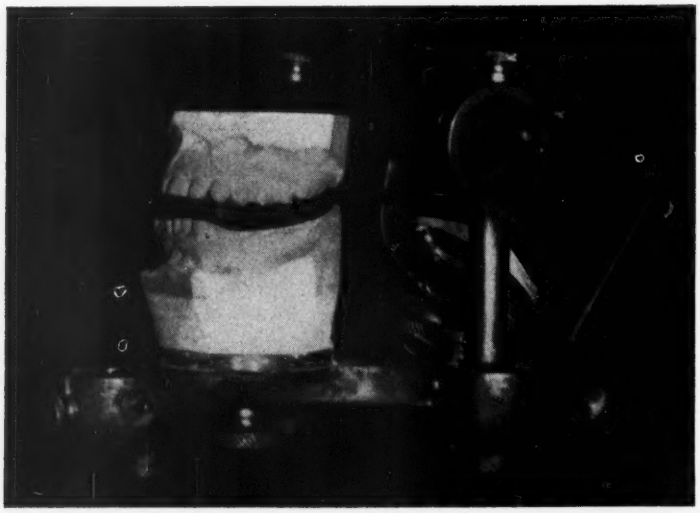

Fig. 4—The maxillary cast is separated from the upper member of the articulator, and fitted accurately into its occlusal index according to the positional relation obtained from the patient.

its attachment to the articulator. Several holes are drilled through the luting plaster and into the stone cast by means of a carbon steel drill No. 42 in the dental handpiece. These holes are drilled in a vertical direction, and at various angles to the vertical (Fig. 2). Some articulators are so constructed that it is impossible to drill holes in a vertical direction, but this does not make any difference, for any angle from the vertical will effect the same end result. A straight angle dental bur is the same diameter as a No. 42 drill. These burs or nails of the same diameter are placed into these various holes. They should pass without

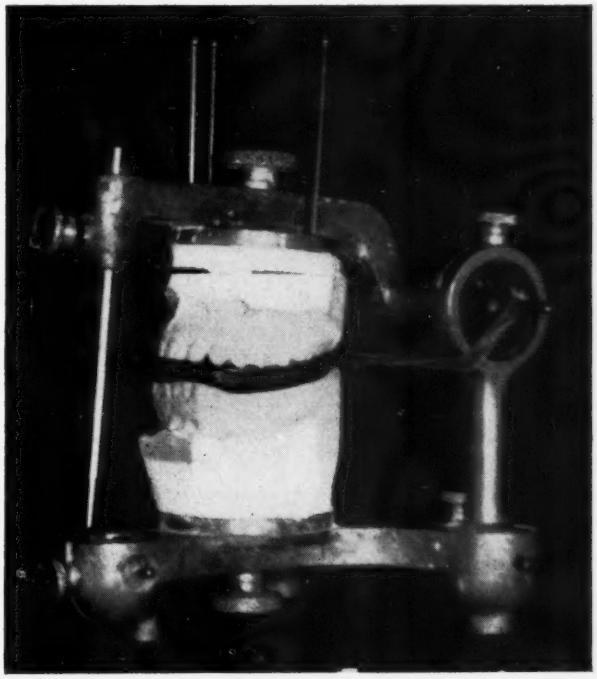

Fig. 5—The upper bow of the articulator is moved into position over the base of the maxillary cast. If the positioning rods cannot be placed through the luting plaster into the cast, the articulator does not reproduce the relationship obtained from the patient. Here the perceptible space between the plaster and the stone cast is further proof that the articulator does not reproduce this relationship.

difficulty into the cast (Fig. 3). A No. 9 round bur for the straight handpiece can also be used for drilling the holes through the luting plaster and stone cast although it does not cut as efficiently as a carbon steel drill. These metal positioning rods are taken out, and the maxillary cast is also removed from the luting plaster.

A plaster, compound, or wax checkbite of any desired positional relation of the mandible should be carefully obtained from the patient. This is placed on the occlusal surfaces of the teeth of the mandibular cast, and the detached maxillary cast is properly positioned in its correct relation to the checkbite (Fig. 4). The

upper member of the articulator is then moved to contact the base of the maxillary cast. If the articulator can accurately duplicate the jaw relationship obtained from the patient, it should be possible to place the metal positioning rods through the luting plaster into the maxillary cast in all the various holes which were drilled. If the articulator does not duplicate this relationship, the metal rods cannot be correctly positioned into the cast (Fig. 5).

The split cast method is the only scientific method to check positional relationships of the patient on the articulator. It should be used to verify the claims of the proponents of the various articulator techniques and instruments.

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PROVE THE ARTICULATOR

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ALL DENTAL operations of any magnitude must pass through an articulator eventually. There appears to be no escape unless it be lifetime possession of a perfect set of perfectly articulated teeth. This is indeed rare. The articulator would, then, appear to be one of dentistry's most important tools; quite possibly, its *most* important one. If this be so, the articulator needs to be examined with hypercritical eyes. So, too, must every procedure that utilizes an articulator come under the sharpest scrutiny. It is the purpose of this writing to outline a method of judging the value of an articulator and, at the same time, determine the accuracy of the mounting.

Ways of mounting jaw relation records in an articulator are so well standardized as to require no review here. Consequently, we may start with means of determining whether the mounting copies the head terminal relationships properly. It should not be necessary to argue that an inaccurate mounting can never produce decent occlusion and should be discarded ruthlessly. The same may also be said of an inaccurate instrument. To accept inaccuracies in either would constitute a health menace, not a health service.

A test of mounting may be made with a dentulous or an edentulous patient. If the patient is dentulous, accurate stone occlusal reproductions are necessary. If the patient is edentulous the occlusion rims should first be built up in hard baseplate wax upon permanent metal bases. Baseplates should never be used. This applies whether the latter be of shellac or of the fitted type. Finished dentures in plastic will never duplicate baseplate mountings exactly. It is easy to see what happens to the articulation when the denture base position on the tissues differs from a baseplate position on the tissues.

For the dentulous patient, one thickness of baseplate wax is warmed and cut to a shape and size that will enter the mouth readily, yet cover the occlusal surfaces of the teeth on both sides. This wax wafer is softened in water at approximately 140°F. It is inserted in the mouth and the patient is instructed to touch the teeth lightly to the wax with the condyles in their hinge position.[1] Numerous slight indentations resulting from the contact of cusp tips with the wax will result. The closure must not be hard enough to pierce the wax and strike opposing cusps. This would create a cuspal guidance that might draw the condyles out of their hinge position. The wax is allowed to harden as much as possible in the mouth

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without the aid of water or compressed air. It must be removed carefully to avoid any distortion from handling. Finally, it should be allowed to finish the hardening process slowly and naturally at room temperature. Sudden applications of cold water or air will warp wax and are to be avoided.

The wax check bite is now taken to the articulator. The wafer is fitted to the teeth of one or the other of previously mounted stone casts and the instrument is closed carefully and lightly. Every cusp tip of every upper and lower tooth must occupy its respective niche exactly as did the cusps in the mouth. If this proves to be the case, the mounting is probably correct. To make sure, the procedure should be repeated.

When the teeth in the articulator will not accept the wax check bite, the fault may lie either with the check bite or the mounting. If repeated check bites are refused by the mounting and the discrepancy looks to be the same each time, the fault lies with the mounting. Using one of the check bites that appears representative, the lower cast should be remounted in the articulator. If the new mounting accepts other check bites, the mounting may be judged to be accurate.

At this point, we have adequate proof of a static, a so-called "centric relation" mounting only. This may indicate the likelihood of good "centric occlusion" but it does not prove articulation. The latter involves not just statics but kinematics as well. The static mounting has, however, accomplished one more thing. It has produced a check bite using the same surfaces that will be used in the finished dentures. Where a centric relation record is used, this is extremely important. The most perfect centric check bite and mounting are worthless where the type of occlusal surfaces has been or is to be changed. It is, for instance, impossible to change from simple surfaced occlusion rims to complicated surfaced cuspation without ruin to the articulation when the change is made while using a centric relation mounting. This sad result will occur even though the vertical dimension be maintained exactly. The aggravating consequences are to be seen in almost every dental office in the land almost every day. As a kinematic control, centric relation is worthless.

The foregoing proved only that the *mounting* was correct. This can be done in *any* articulator from the most complicated to the simplest. It is now necessary to determine whether the articulator chosen is suitable for the kinematics involved in opening and closing the case while the teeth are being set up. If it is not, it will affect the dentures adversely.

TEST FOR ARTICULATING TEETH

It has been proved for one-quarter of a century that the initial opening and final closure of the jaw can be done with pure hinge motion. Some patients can separate their teeth as much as an inch or more at the incisors before the condyles begin to slide forward. That being the case, a patient can produce hinge bites at any opening that does not exceed his hinge range. These bites will all close on arcs having a common center. This makes it simple to use any proved static mounting to test any articulator for its value in duplicating the final closure of the jaw.

To do this, we need merely test the ability of the articulator to accept different thicknesses of wax bites that have been taken in the mouth.

Several wax bites at various jaw openings are taken in the mouth. The patient's jaw should be in the hinge position in every instance. Most patients can produce bites up to six and even eight thicknesses of baseplate wax before exceeding their hinge range. If the articulator has the ability to duplicate the simple opening and closing movements of the jaw (it is worthless if it does not) it will accept these bites with their various vertical openings as readily as it accepts the original static bite. Once more, this does not mean approximately. It means exactly.

The majority of the wax bites should be made to show only slight cusp indentations. However, at least one bite should be taken with wax of considerable thickness and with deep tooth registrations. When this last type of bite is tested in the instrument, the teeth should drop into their slips smoothly and without a hitch. It should never be necessary to use even the slightest force to insert them completely.

For the edentulous patient, the articulator mounting is made to a deliberately over-opened bite. The upper occlusion rim should be elongated about one-quarter inch. Once mounted, the overlong upper occlusion rim is softened in water at 140°F. The lower occlusion rim is left hard but is notched. Both are put in the mouth and the patient is instructed to bite hard with the condyles in hinge position. This will close the vertical dimension part way and make unmistakable apposing marks in the rims by which they may be fitted together.

The upper and lower occlusion rims are then returned to the articulator and checked. If the instrument controls are correct duplicates of the patient's hinge-axes and craniomaxillary relationships, the changed upper and lower occlusion rims will fit each other as perfectly in the articulator as in the mouth. If desired, the closure may now be finished in the articulator, and when returned to the mouth the latter will accept the new vertical dimension instantly. In other words, the vertical dimension may be changed at will, either on the instrument or in the head, when the articulator is an accurate instrument set to kinematic controls that duplicate the natural kinematic controls in the patient's head.

CONCLUSION

If a simple bite can stand up under the test for a static centric relation mounting, the mounting is correct. If the articulator can prove itself capable of accepting bites at various jaw openings and wax bite thicknesses, it shows itself a tool fit to produce the therapeutic remedy for which the patient sought the dentist's help. In the absence of either or both of these proofs, there is no reason to continue. Dentistry's first duty to its patients is tissue preservation. Malarticulated teeth are well known as viciously destructive forces, the antithesis of tissue preservation.

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A SHORT SURVEY OF THE PRINCIPLES INVOLVED IN THE ESTABLISHMENT OF BALANCED OCCLUSION

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IN A SERIES of articles and lectures Karolyi (1901-1907) drew attention to the consequences following upon overstrain to the supporting structures of the teeth. His words, however, found little response at that time, and it has been left to others since then to investigate further the problem of articulation.

During the period from 1916 to 1926, Stillman, McCall, and others pointed out that under unfavorable conditions, producing the so-called "traumatic occlusion," the strain of one individual tooth may exceed the margin of safety optimal for the tooth, in which case the supporting tissues are progressively destroyed. At that time, however, overestimation of the importance of the strain factor was given, in the belief that this was the principal cause of pyorrhea alveolaris.

Today it is realized that something more than overstrain is required, and research is proceeding to determine the factor that specially predisposes certain individuals, certain families, and certain races to the disease.

It is, however, an indisputable fact that overloading an individual tooth, or teeth, may be a precipitating cause in stimulating a latent disease factor, and unless this overstrain is corrected, a relapse will follow local methods of treatment. It is the purpose of this paper to show the results of overloading, or, conversely, lack of physiologic movement of teeth, on the paradontium. A brief survey is included on the methods used for the re-establishment of occlusal harmony.

DEFINITION

Many terms have been used to describe the state of functional occlusion, and in 1943 Miller defined balanced occlusion as "the natural closure and fitting together of the maxillary and mandibular teeth, their relationship when closed or during excursive movements of the mandible, whereby maximum masticating efficiency and periodontal preservation are obtained."

The ideal state of balanced occlusion of the natural dentition exists, then, when each tooth is in contact with its antagonist in such a way as to subject its supporting tissues to stresses which they are best suited to withstand. Simultaneous contact between antagonists during normal functional movements is, of course, always desirable.

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Histologic evidence has shown that bone is, biologically, a plastic tissue, sensitive to pressure and readily undergoing resorption when subjected to stress in excess of normal requirements.

Fig. 1 shows resorption of the outer plate of bone in the upper left canine region following excessive overload in a locked occlusion. This condition would lead to loosening and finally to loss of the tooth. Any tooth which acts as an

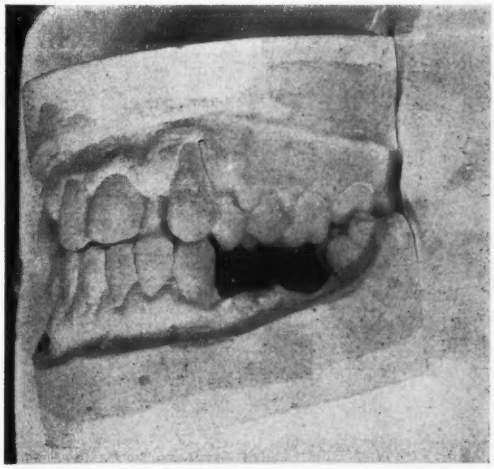


Fig. 1.—Resorption of the outer plate in $\underline{|3}$ region, following overload in "locked occlusion."

Fig. 2.—Premature contact between $\frac{7|}{6|}$ in habitual centric occlusion.

impediment to the free gliding movement of the jaw will be repeatedly subjected to unilateral trauma. If this force exceeds the margin of safety of the supporting tissues of the tooth, and if the resistance of the supporting tissues is impaired by a predisposition to paradontal disease, the paradontium will undergo progressive destruction.

Fig. 2 shows a case where occlusion is confined to $\frac{7}{6}|$ in all excursions of the mandible, while Fig. 3 shows $|\frac{4\ 5}{4\ 5}$ which on lateral movement were "rocked" by tip contact only. These four teeth were quite loose, whereas $\frac{7}{6}|$, being multi-rooted teeth, with no cusp inclines, were firm and showed radiographically some evidence of osteosclerosis.

Decreased function, which can be observed in teeth which have lost their antagonists, leads to a diminution of supporting bone substance. Here, the spongy bone shows marked rarefaction, the bone trabeculae are less numerous and very thin, and the periodontal membrane becomes narrower owing to loss of function of the teeth.

Fig. 3.—Left side of case shown in Fig. 2. Tip contact only between $|\frac{4\ 5}{4\ 5}$.

BALANCED OCCLUSION

The *main factors* for consideration in the establishment of balanced occlusion can be summed up under the four headings: (1) true centric occlusion; (2) free lateral gliding movements; (3) equal distribution of stresses; (4) the retention or re-establishment of the physiologic occlusal vertical dimension.

1. *True Centric Occlusion.*—In general, the term centric occlusion is rather loosely applied to a clenching of the teeth in what appears to be a normal closed-jaw relationship. Sometimes, however, owing to the loss of teeth or an irregular position of certain teeth, the mandible, on closure, is compelled to assume an habitual forced position.

Fig. 4 shows how cusp interference between $\frac{7}{7}|$ has driven the mandible forward to assume a position which has been called the *habitual centric occlusion* (Fig. 5) as opposed to the *true centric occlusion,* which is assumed on closure in the absence of cusp trauma.

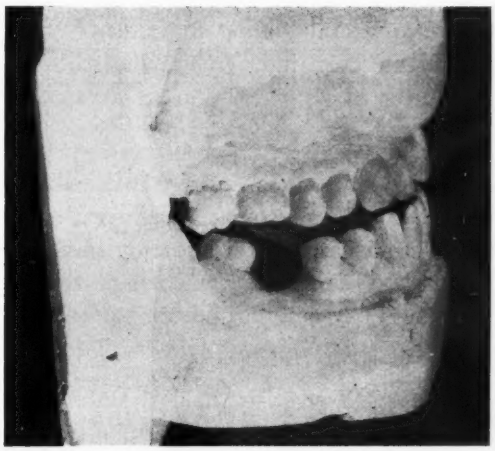


Fig. 4.

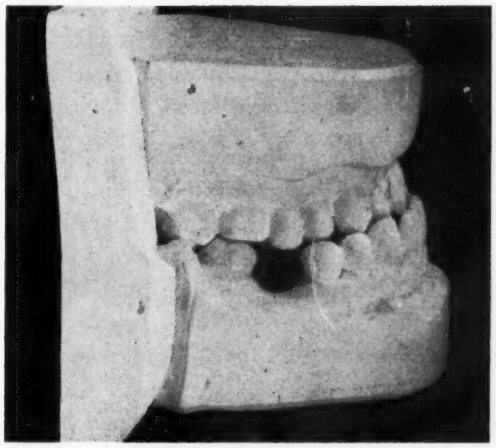


Fig. 5.

Figs. 4 and 5.—Cusp interference between $\frac{7}{7}|$ shown in Fig. 4, forces mandible to adopt forward position (Fig. 5).

True centric occlusion may be defined as "the centric position of the lower jaw in relation to the upper, in which the condyles are at rest in their most distal unstrained relationship, in each respective glenoid fossa, from which lateral movements can be made."

Teeth in true centric occlusion should, ideally, be subjected to axial stress only, with a force, the maximum intensity of which is controlled by muscle tension, reaching its correct physiologic degree of contraction at the normal occlusal vertical dimension.

2. *Free Lateral Gliding Movements.*—It has been shown that lateral stresses, to the point of overloading, can cause progressive destruction of the tooth supporting tissues, so that free lateral gliding movements should be established by selective grinding to eliminate cusp interference. Grinding is conducted carefully by following the rule, defined below, *to avoid any reduction in the occlusal vertical dimension.*

Cusp inclines can be prominent in youth when the alveolar support is strong, but should be reduced either naturally or artificially with increasing age. It may happen that with steep cusps a patient will bite only in centric occlusion, showing complete absence of conscious lateral movements, at the same time performing unguarded lateral movements at night (bruxism) under such strong stress as to injure the paradontal tissues.

3. *Equal Distribution of Stresses.*—An ideal state of occlusal equilibrium is sought to ensure that all teeth will be as uniformly stressed as possible during mastication.

4. *The Normal Occlusal Vertical Dimension* is the measurement, in a young adult with all teeth fully erupted in closed position, between the base of the nose and the symphysis menti. It includes a harmonious relationship between elevator and depressor muscles which act on the mandible, as well as a physiologically correct position of each condyle in the glenoid fossa.

Any artificial increase above the normal occlusal vertical dimension will result in depression of the elevated tooth or teeth, until the normal dimension is again established. This has been seen to occur bilaterally, and to affect bicuspids and molar teeth when an overlay appliance was inserted which exceeded the normal vertical dimension. In most cases, following re-establishment of the normal vertical dimension, the teeth and supporting tissues return to normal, providing that the trauma is not of long duration.

To disturb or not to disturb the vertical dimension is a question with which we are often confronted. Certain conditions which render it advisable to change the verticle dimensions are: esthetic considerations; pathologic conditions such as periodontitis and its sequelae; and functional requirements and disturbances in the temporomandibular joint resulting from vertical dimension abnormalities.

A simple rule for all cases is never to increase the vertical dimension unless it is found to be essential, after careful consideration has been given. In every case a check-up should be made, by standardized radiographs, to ensure the correct position of the condyle in the glenoid fossa—a technique outside the scope of this paper.

DIAGNOSIS

It cannot be too strongly emphasized that the successful outcome of treatment depends entirely on the accurate accessment of all factors involved, and to that end a careful and methodical analysis of the occlusion forms the basis of diagnosis.

Occlusal Analysis.—Accurate study casts in stone plaster of both upper and lower jaws are essential, the casts being first placed in occlusion to find if any inequalities exist owing to air-blows in the impressions. Following the face-bow registration, the upper cast is mounted on an anatomic articulator of the Hanau or Dentatus pattern. The cast is mounted in the Frankfort plane horizontal, in order that deviations from the supposed ideal can be observed more easily, and in addition such a standardized procedure renders possible a comparative study of different cases. The relationship of the lower cast to the upper is ascertained by taking a wax checkbite in the patient's mouth with the mandible in the rest position. Great care should be exercised to ensure that no cusp contact is permitted through the wax, otherwise registration of the true centric position may not be established. Individual condylar path registrations, which may vary for either fossa, are obtained from a protrusive checkbite taken in soft wax.

The *principal conditions* which demand the establishment of occlusal harmony can be summarized as follows: (a) those cases in which there is no loss of teeth, and which show evidence of recurrent gingival and periodontal disease; (b) those cases with some loss of teeth, showing tipping of some teeth and elongation of others, but with no loss of occlusal vertical dimension; (c) those cases with loss of some posterior teeth and loss of vertical dimension—a condition in which "locking" of teeth sometimes occurs with resultant periodontal injury; (d) edentulous cases, with which we are not concerned in this paper.

A clear indication of a shortened vertical dimension is often given by the lingual inclination of the remaining posterior teeth. It seems a curious fact that the so-called natural deep-bite cases, where lateral movement is nonexistent, show a marked resistance to periodontal disease.

TREATMENT

There are three principles involved in the establishment of balanced occlusion, but, before treatment is attempted in the mouth, methodical planning in stages of the requisite adjustments must be undertaken on the casts, which are articulated by the methods already explained. These principles may be classified accordingly: (1) orthodontic treatment; (2) selective grinding; (3) prosthetic reconstruction: (*a*) without changing the height of the occlusal vertical dimension; (*b*) with reestablishment of the occlusal vertical dimension where possible.

1. *Orthodontic Treatment.*—This is not necessarily restricted to children, but may be of value in the adult. Cooperation with the orthodontist is desirable.

2. *Selective Grinding.—First, the true centric occlusion* is ascertained by relieving the high spots on the stone cast teeth by scraping the premature contacts

in accordance with *a definite rule*—namely, reduce the cusp if this makes premature contact in all positions; otherwise deepen the fossa.

The contacts are shown by occluding the jaws in the centric position on thin articulating paper, and relieved until simultaneous contact is obtained between the arches from, at least, the canine backwards on each side. A note is kept, step by step, of the individual tooth cusps scraped.

Secondly, the protrusive check-bite is adjusted, remembering that enthusiasm for the establishment of the ideal must not outweigh the appreciation of the esthetic.

In most cases it will be found that the ideal state of equal stress distribution is not attainable in the protrusive position owing to depth of the vertical overlap, etc., and a compromise must be accepted. However, it is often the case that the reduction in height of overlong central incisors not only will redistribute their biting load, but also will materially help to improve appearance. In all events, grinding in the protrusive position should almost entirely be confined to the upper incisors, since, if reduction in height of the lowers is effected, contact in centric occlusion will be lost, and upward growth of these teeth may follow.

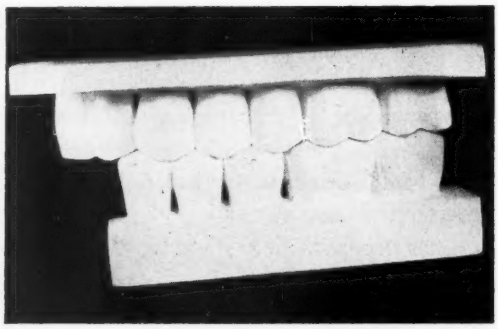


Fig. 6.—Models showing harmonized cusp inclines.

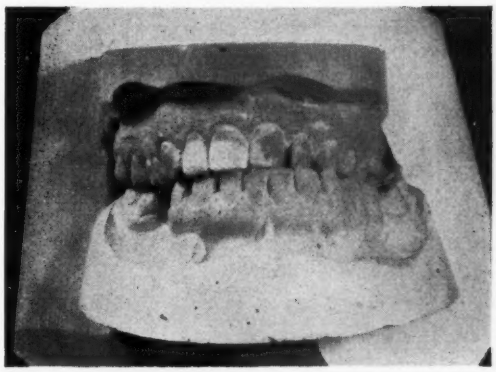
Thirdly, right and left lateral movements are examined in turn, covering the whole arch with thin articulating paper. The lower jaw is moved to one side at a time. Excessive lateral stress on the bicuspids and molars is countered by a reduction in cusp inclination, but in order to avoid any lessening of the vertical dimension, care must be exercised to ensure that only those cusps unconnected with the retention of the vertical height of the occlusion in centric position are ground.

Assuming the existence of a normal side-to-side relationship between upper and lower posterior teeth, in which the vertical dimension is maintained by the buccal cusps of the lower teeth and lingual cusps of the upper, it is obvious that any reduction of these particular cusps will produce a lessening in the vertical dimension. The reverse is true in a cross-bite.

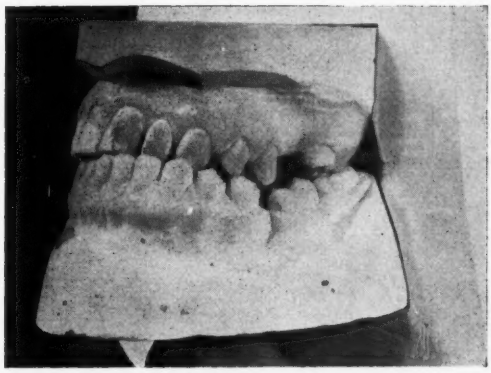
Accordingly, when correcting interfering cusp inclines, or premature contacts in the lateral movement, carry out the following rule:—*grind on the working side: b*uccal *u*pper, *l*ingual *l*ower, and on the *balancing side,* the buccal cusp in the lower, which must not be reduced in height but merely faceted on its

lingual plane. The above rule can easily be memorized by taking the first letter of cusps to be ground and representing word *"Bull."* It is worthy of note that even on the working side, the tips of the cusps are not always ground, but the adjustment is confined to a bevelling of their facets in order to harmonize gliding inclines (Fig. 6). In cross-bite the above rules are reversed.

When all movements have been analysed on the articulator and adjustments made, then, and then only, should the same grinding be repeated in the mouth.



A.



B.

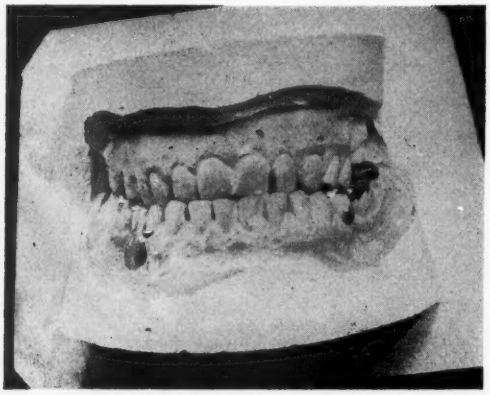
Fig. 7.—Left canine cusp interference resulting in lateral displacement of mandible.

3. *Prosthetic Reconstruction.—*

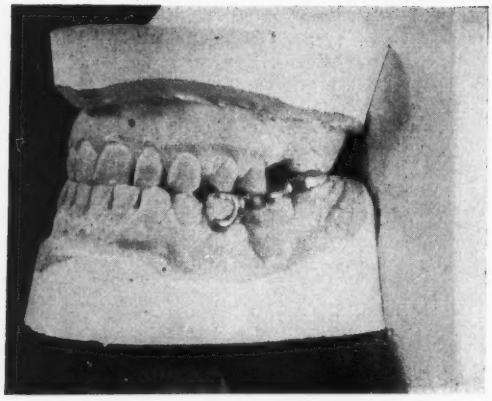
(a) *Without Changing the Occlusal Vertical Dimension:* To prevent over-eruption and/or tipping and drifting of teeth, it is clear that early replacement of an extracted tooth is necessary. Whether or not agreement is reached on the advantages or disadvantages of fixed partial dentures over removable partial dentures, the aim involved in the reconstruction of the occlusion is the same—namely, the re-establishment of the complete arch with all teeth working in functional harmony with their antagonists. Such restoration implies not only the replace-

ment of missing teeth but also the lengthening of any teeth not in occlusion by means of overlays, etc., in such a way that functional stimulation is given to the supporting tissues.

Figs. 7 and 8 show a case where left canine cusp interference resulted in the lateral displacement of the mandible to the left side in an habitual centric occlusion. The teeth were ground into true centric occlusion and stabilized by means of an overlay appliance bringing into contact those posterior teeth previously out of occlusion.



A.



B.

Fig. 8.—Treatment of the displacement shown in Fig. 7, by stabilizing the true centric occlusion with an overlay appliance, after preliminary grinding of natural teeth.

(b) *With Re-establishment of the Occlusal Vertical Dimension:* It can be said, as a rule, that loss of posterior teeth usually results in decrease of the occlusal vertical dimension and will often result in locking of the occlusion on closure (Fig. 1). In the case of the deep occlusion, lessening of the vertical dimension will be attended by additional symptoms. The lower anterior teeth strike the palatal gingivae, while sometimes a reciprocal trauma is caused by the upper incisors on the labial gingivae of the lower incisors.

Splaying of the upper incisors is often seen as in Fig. 9, and it is interesting to notice that in this case premature contact (Fig. 10) between $\left|\frac{4}{4}\right.$ is causing a forward thrust of the mandible from its true centric into its habitual centric occlusion (Fig. 11).

Prognathic cases are similarly affected, but in reverse order to the deep-bite cases. Here the lower anterior teeth may spread and the symphysis menti move forward and upward (Fig. 12).

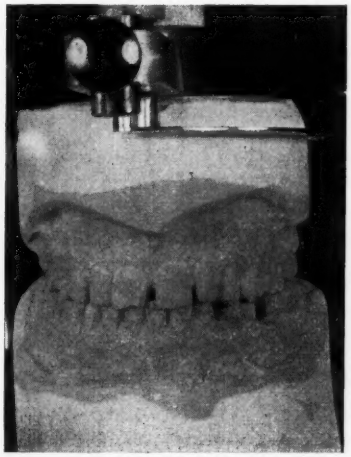


Fig. 9.

Fig. 10.

Fig. 11.

Figs. 9 to 11.—Fig. 9 shows splaying of upper incisors, caused by the forward thrust of mandible, due to the premature contact between $\left|\frac{4}{4}\right.$ (Fig. 10). Habitual centric occlusion is shown in Fig. 11.

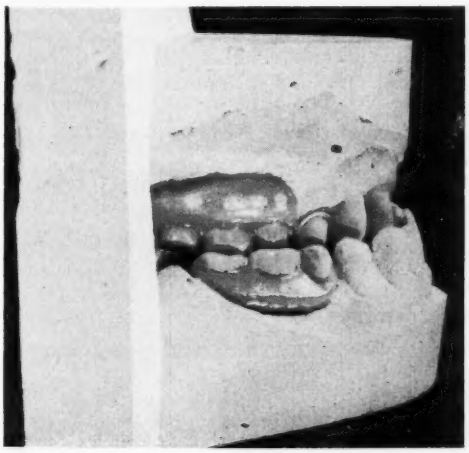


Fig. 12.

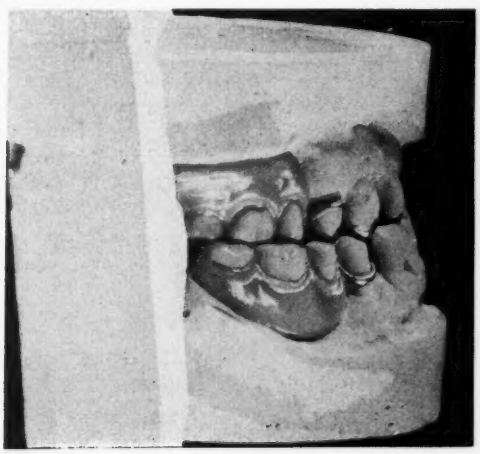


Fig. 13.

Figs. 12 and 13.—Before and after the occlusal vertical dimension had been restored in true centric occlusion.

The restoration of the true vertical dimension re-established functional stimulation of the incisor supporting tissues, and in addition resulted in an improved esthetic result, in profile (Fig. 13).

SUMMARY

1. A definition of balanced occlusion is given, with a brief reference to histologic conditions resulting from occlusal imbalance.

2. The main objects concerned with the establishment of occlusal harmony are described. It is stated that balanced occlusion is considered to include the functional equilibrium of the entire masticating mechanism.

3. Occlusal analysis forms the basis of diagnosis, and, accordingly, a description is given, emphasizing the importance of accurate assessment of all details prior to treatment in the mouth.

4. A classification of conditions in which balanced occlusion plays a vital part is stated.

5. Treatment is described, with particular reference to selective grinding. The main ideals of prosthetic reconstruction are explained and photographs are shown of cases treated.

I wish to acknowledge my indebtedness to Mr. Hamish Thompson and Mr. W. Stewart Ross for reading the manuscript of this paper, and to Mr. Bligh, of the Photographic Department, University College Hospital, for the photographs.

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A GUIDE TO THE ORIENTATION OF THE PLANE OF OCCLUSION

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FULL denture prosthesis is the dental specialty which places the greatest number of important factors in the control of the operator. Though the operator is free of the detailed consideration of relative tooth position, tooth mobility, periodontal involvement, and caries, he faces a new complex problem. He is concerned with the shape, size, and relative position of the ridges; the positioning of the artificial teeth in relation to the ridges; the arrangement of the anterior teeth for esthetics; the determination of the incisal guidance angle; condylar function and the combined influence of the incisal guidance angle and condylar function on the orientation of the plane of occlusion and the curve of Spee. All these factors must be carefully considered in order to provide dentures that function successfully. One can, without going into detail, appreciate the modifications of tooth form and size required by alterations in condylar function, the incisal guidance angle, the curve of Spee, and the orientation of the plane of occlusion. The interrelation of these various factors is conspicuously apparent. The more guides there are to these factors, the simpler the task. Various methods of recording mandibular function, vertical dimension, incisal guidance angle, and tooth form have been devised and advocated.

The purpose of this paper is to present a guide to the orientation of the plane of occlusion based on a consideration of anatomic landmarks. This study was undertaken to determine whether or not there was any correlation between fixed cranial landmarks and the plane of occlusion. It was necessary to select points of reference that would not be affected either by degenerative processes or surgical interference, and that could readily be identified on an edentulous maxillary cast. The hamular notches and the anterior nasal spine were chosen since they are constant to both the maxillary cast and the skull.

In an effort to determine whether there was a predictable relationship between these landmarks, the following measurements and correlations were made on twenty-six skulls. The skulls were positioned with the Frankfort plane in a horizontal position. Adjustable indicators were constructed so they could be positioned to point to the right and left infraorbital foramen. A rod was fashioned in an ex-

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aggerated U form with its deepest part parallel to both extensions. The bend was incorporated in this rod to avoid interference with the ascending ramus when the rod was positioned on the skull. The bent rod was used to indicate the alignment of the right and left hamular notches.

The skulls were first photographed from their lateral aspects, and the following lines were drawn on the photographs* (Fig. 1):

1. The Frankfort plane

2. The plane of occlusion. The plane of occlusion as used in this research was accepted as a line drawn from the tip of the lower cuspid to the crest of the

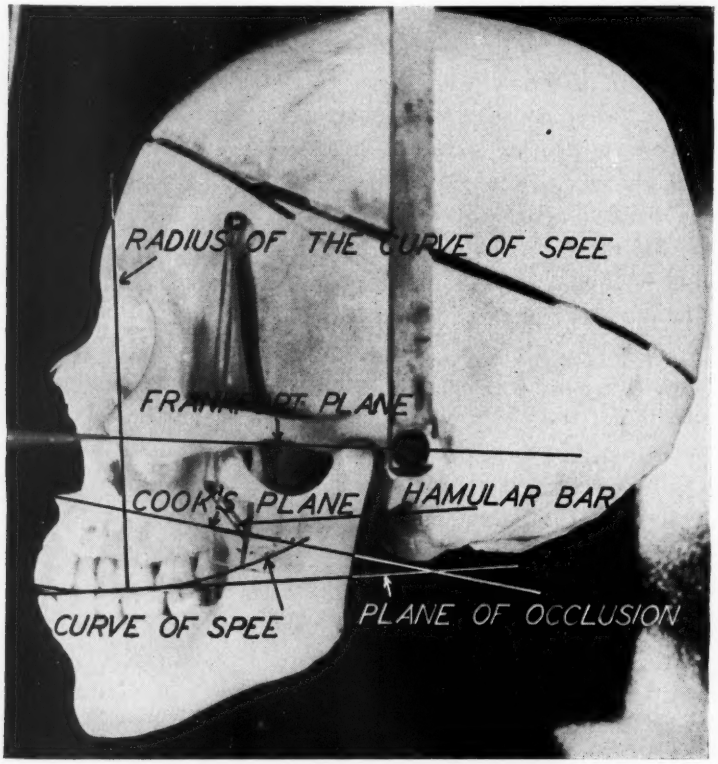

Fig. 1.—A typical photograph of a skull with the various reference points and planes.

distobuccal cusp of the lower second molar. In skulls where the key teeth of the plane could not be visualized, were loose, or were missing, a method was devised to ascertain their location by making use of the curve of Spee. A series of transparent disks of varying radii were superimposed on the photograph. When the curve of a disk coincided with the greatest number of buccal cusps, the position of of the cusp in question was approximated on its circumference.

*The photographs were enlarged to a 1 × 1 relationship before any measurements were made. Had there been any minor unrecognized discrepancies introduced during the mechanics of the photographic process, their effect would be negligible for the deductions made in the research are based on a proportionate relationship.

3. Cook's plane. A line from the superior aspect of the hamular notch rod to the anterior nasal spine.

The following measurements were then made on the photographs. The distance from the anterior nasal spine to the plane of occlusion, on the right side, ranged from 12 to 34 mm. and averaged 25.5 mm. On the left side, it ranged from 20 to 30 mm. and averaged 25 mm. The distance from the hamular notch rod to the plane of occlusion on the right side ranged from 7 to 17 mm. and averaged 10 mm. On the left side, it ranged from 5 to 15 mm. and averaged 10 mm.

The difference between the measurements from the anterior nasal spine to the plane of occlusion and from the hamular notch line to the plane of occlusion on the right side ranged from 5 to 22 mm. and averaged 15.5 mm. On the left side, it ranged from 11 to 20 mm. and averaged 15.5 mm. The distance between the anterior nasal spine and the hamular notch rod on the right side ranged from 40 to 55 mm. and averaged 47 mm. On the left side, it ranged from 40 to 57 mm. and averaged 46.5 mm. The angle formed by Cook's plane and the plane of occlusion on the right side varied from 12 to 27 degrees and averaged 19 degrees. On the left side it varied from 13 to 26 degrees and averaged 19 degrees.

A preliminary correlation of the measurements derived from the lateral skull photographs indicates that there is some predictable relationship between the distance from the hamular notch to the anterior nasal spine and the angle formed by Cook's plane and the plane of occlusion. The greater the distance between the anterior nasal spine and the hamular notch rod, the more acute the angle. The shorter the distance, the more obtuse the angle. (Table I.)

The skulls were then photographed from the frontal aspect and the following horizontal lines were drawn (Fig. 2):

1. The infraorbital foramen line at the superior border of the infraorbital foramen.

2. The hamular notch line at the superior aspect of the hamular notch rod.

3. The plane of occlusion at the anterior aspect of the plane of occlusion. This line was determined by joining the right and left planes of occlusion as determined on the lateral skull photographs.

Because of its intermediate position, the hamular notch line was used as a base line in determining the degree of variation between it and the infraorbital foramen line, and between the plane of occlusion and the hamular notch line. In determining degrees of variation, a line perpendicular to the hamular notch line was drawn between the right and left central incisors. A downward deviation off the parallel to the left of center was considered a minus deviation, and an upward deviation off the parallel to the left of center was considered a plus deviation. Of the twenty-six skulls measured, one was parallel; thirteen were minus deviations, the greatest of which was —3 degrees; thirteen were plus deviations, the greatest of which was +2 degrees. The deviation of the infraorbital line from the hamular notch line ranged from —3 to +2 degrees. The average deviation ranged between —1.3 and +1.2 degrees. The same conditions were

TABLE I.*

1	2		3		4		5		6		7	8	9	
	R	L	R	L	R	L	R	L	R	L			R	L
1	25	26	8	10	17	16	50	52	20	19	−3.0	+1.0	−3	−2
2	26	25	9	12	17	13	55	57	18	13	−3.0	0	NI −1 mm.	OI
3	24	24	10	9	14	15	50	44	15	19	+0.5	0	+6	+5
4	30	28	8	10	22	18	49	45	26	25	+0.5	−1.5	−3	OI
5	26	25	11	13	15	12	47	52	19	15	−1.5	0	−0.5	−1
6	21	21	8	5	13	16	40	40	20	24	−0.5	−0.5	−2	−2
7	24	25	12	11	12	14	53	52	14	15	−1.0	+0.5	+4	+4.5
8	29	26	15	10	14	16	46	47	13	21	+1.0	−1.5	+4	+2
9	29	28	8	12	21	16	41	45	30	20	−2.5	−6.0	−2	OI
10	24	24	9	7	15	17	39	44	23	22	+2.0	0	+2	OI
11	29	28	15	8	14	20	49	46	12	26	+1.5	−1.5	OI	OI
12	27	27	9	8	18	19	45	45	23	26	−1.0	0	OI	OI
13	27	27	11	10	16	17	55	53	16	19	+0.5	−1.0	+1	+1
14	25	23	10	11	15	12	49	56	18	13	−0.5	0	+3	+1
15	34	30	14	14	16	16	49	45	24	21	+0.5	−0.5	—	—
16	27	28	7	8	20	20	47	50	27	22	−0.5	+2.0	−2	−2
17	25	25	11	12	14	13	42	50	21	14	−0.5	−1.5	+1	−2
18	25	26	8	11	17	15	42	49	25	18	0	0	OI	+1
19	27	25	9	11	18	14	49	42	25	17	−0.5	+0.5	OI	OI
20	34	30	17	15	17	15	45	55	22	16	−1.5	−2.0	−2	NI +2.5
21	20	21	7	5	13	16	42	45	18	20	+1.5	−1.0	NI −2 mm.	OI
22	25	26	8	7	18	19	42	49	24	23	+1.0	0	NI −1 mm.	OI
23	26	25	11	12	15	13	45	48	19	17	+2.0	+0.5	−2	+3.5
24	23	23	13	6	10	17	45	45	14	23	+3.0	−2.0	NI −2 mm.	+2
25	12	20	7	5	5	15	43	45	13	19	+1.5	0	+5	+2
26	24	22	8	11	16	11	52	44	19	15	−1.0	+2.0	−4	+2
Averages and Collation														
	25.5	25	10	10	15.5	15.5	47	46.5	19°	19°	(13) −1.3 (13) +1.2 (1) 0	(11) −1.7 (6) +1.1 (9) 0	(9) −2.3 (8) +3.3 (4) I (2) −1 (1) −1 (2) −2	(5) −1.8 (10) +2.4 (9) I (1) +2.5

*_Legend_ (all measurements are in millimeters):

Column 1 Skull number.
Column 2 (Right and left.) Measurements of the distance of the anterior nasal spine to the plane of occlusion.
Column 3 (Right and left.) Measurements of the distance of the hamular notch to the plane of occlusion.
Column 4 (Right and left.) Difference of measurements between Columns 2 and 3.
Column 5 (Right and left.) Distance between the hamular notch and anterior nasal spine.
Column 6 (Right and left.) The degree of the angle formed by Cook's plane and the plane of occlusion.
Column 7 The degree of variation of the infraorbital plane from the hamular notch bar line.
Column 8 The degree of variation of the anterior aspect of the plane of occlusion and the hamular notch bar line.
Column 9 (Right and left.) The degree of variation between the occlusal plane line as determined by the cuspid-molar plane and the plane as determined by projecting a tangent to the curve of Spee from the mesiobuccal cusp of the first molar. _I_, Identical planes; _NI_, not identical planes; _0_, no degree of divergence between the planes. (Plus or minus variations when planes were parallel and not identical measured in millimeters.)

used in measuring the deviation of the line of the plane of occlusion from the hamular notch line. Of the twenty-six skulls measured, nine were parallel, eleven were minus deviations, the greatest of which was —6 degrees; six were plus deviations, the greatest of which was +2 degrees. The deviation of the line of the plane of occlusion from the hamular notch line ranged from —6 to +2 degrees. The average deviation ranged between —1.7 and +1.1 degrees.

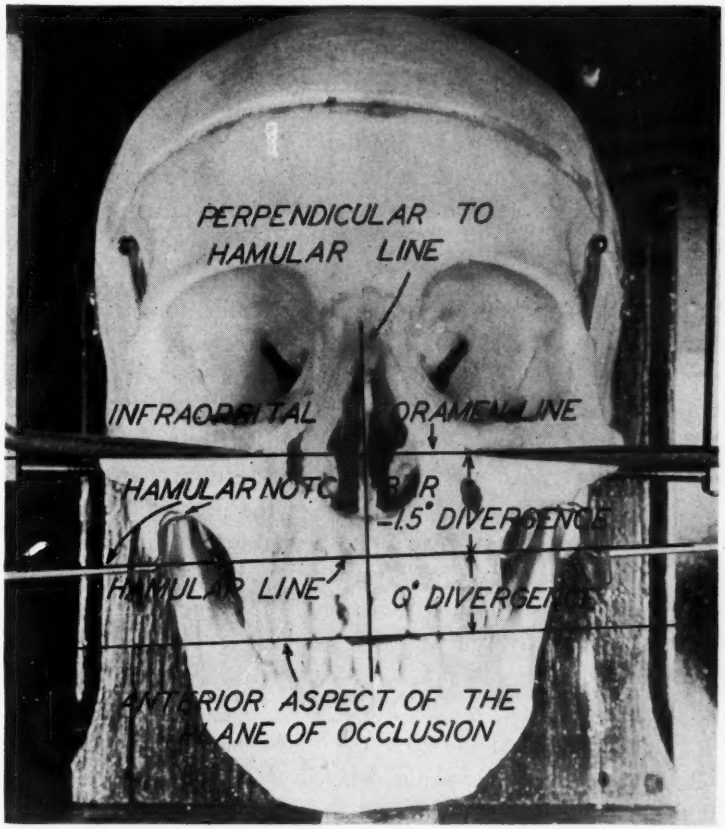

Fig. 2.—A frontal photograph of a skull with the various reference lines.

The comparatively minor variations between these three horizontal lines substantiate the fundamental validity of the suggestion that, within esthetic considerations, the anterior aspect of the plane of occlusion be kept parallel to the pupils of the eyes (Table I.)

The following procedure was undertaken to correlate the observations that had been made. Casts were made of dentulous maxillae. These clearly showed the hamular notches and a well-reflected muccolabial fold adjacent to the labial frenum. The nasal spine was palpated intraorally, and marked with an indelible pencil at the furthermost reflection of the fold adjacent to the frenum. The im-

pressions showed the indelible pencil mark which indicated the position of the nasal spine.

The plane of occlusion marked on the photographs was determined from teeth of the lower jaw. It was necessary to transfer that plane to the maxilla in order to correlate it with the cranial landmarks for use on the upper cast alone.

A series of plastic disks were used to determine the curve of Spee. The radius of the appropriate disk was drawn to the mesiobuccal cusp of the first molar, and a line was drawn tangent to the arc at that point. It was found that, although this line varied somewhat from the plane of occlusion as determined by the cuspid molar line, the difference was not great. Both lines were projected until they intersected, or were observed to be parallel. Where they intersected, the degree of divergence of the lines was measured. The cuspid molar plane of occlusion was used as the base line. If the line tangent to the radius of the curve of Spee was above the cuspid molar line it was designated as a plus variation, if below it was noted as a minus variation.

On the photographs of the right side of the skulls, four of the projected lines were identical with the cuspid molar line. Two were parallel and 1 mm. below the cuspid molar line. Two were parallel and 2 mm. below the cuspid molar line. Nine were minus deviations. The greatest degree of divergence was —4 degrees and the average was —2.3 degrees. Eight were plus deviations. The greatest degree of divergence was +6 degrees and the average was +3.3 degrees.

On the left side, it was found that nine of the projected lines were identical. One was parallel but 2.5 mm. above the cuspid molar line. Five were minus deviations. The greatest degree of divergence was —2 degrees and the average was —1.8 degrees. Ten were plus variations. The greatest degree of divergence was +5 degrees and the averge was +2.4 degrees. (Table I.)

MEASUREMENTS ON CASTS

The degree of variation between the plane of occlusion as determined by the cuspid molar line and the plane derived from the tangent to the curve of Spee at the mesiobuccal cusp of the first molar was slight. It was small enough for purposes of this research to warrant correlating the cranial landmarks and the plane of occlusion on the upper cast alone.

A flat piece of plastic was used to represent the plane determined to be tangent to the curve of Spee. It was placed against the upper cast, and positioned to touch the greatest number of teeth possible. The vertical distances from the plastic plane to the anterior nasal spine, and to the hamular notches were then measured. The distance from the anterior nasal spine to the plane of occlusion varied from 19 to 27 mm. and averaged 21.5 mm. The distance from the hamular notch to the plane of occlusion varied from 4 to 11 mm. and averaged 6.5 mm. The difference between the averages taken from the casts and those derived from the photographs of the skulls can be attributed to the soft tissue. Actually the soft tissue interposed in the area of the hamular notches is rigid enough to resist marked deformation, and thereby provides a constant. The tissue adjacent to

the nasal spine has a similar resistance when the lip is well reflected. The difference between the measurements made on the skulls and on the dentulous casts averaged between 3.5 and 4 mm. These differences were constant at the hamular notches as well as at the anterior nasal spine.

With the plane of occlusion as a base line, and knowing the limits of variation of the angle formed by Cook's plane and the plane of occlusion, the distance from the anterior nasal spine to the plane of occlusion was plotted. The average degree of angulation and the average nasal spine to occlusal plane distance were superimposed (Fig. 3). This provided confirmation of the original observation that there was a predictable relationship between the plane of occlusion, Cook's angle,* the anterior nasal spine to the hamular notch distance, and the anterior nasal spine to plane of occlusion distance.

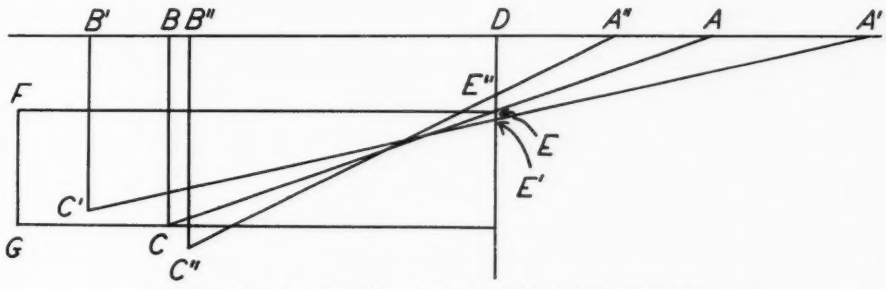

Fig. 3.—A composite diagram of the data in Table I.

Triangle *ABC* represents the average values derived from the twenty-six skulls.

Line *AB* represents the plane of occlusion.

Line *BC* represents the average distance from the anterior nasal spine to the plane of occlusion.

Line *CE* represents the average distance from the anterior nasal spine to the hamular notch.

Angle *BAC* represents the average angle formed by Cook's plane and the plane of occlusion.

Line *DE* represents the average distance of the hamular notch to the plane of occlusion.

Lines *FE* and *GC* are merely extensions from points *E* and *C*, respectively, parallel to the plane of occlusion to form Line *FG*.

Line *FG* represents the average difference between the distances from the anterior nasal spine and the hamular notch to the plane of occlusion.

Triangle *A'B'C'* has been superimposed over the average values to illustrate the alteration of the relative relationships when considering a skull having an angle formed by Cook's plane and the plane of occlusion less than the average angle.

Triangle *A"B"C"* has been superimposed over the average values to illustrate the alteration of the relative relationships when considering a skull having an angle formed by Cook's plane and the plane of occlusion greater than the average angle.

ABC, Average measurements of twenty-six skulls.
- Angle *BAC* = 19 degrees (Column 6L, Table I)
- Distance *BC* = 25 mm. (Column 2L)
- Distance *DE* = 10 mm. (Column 3L)
- Distance *EC* = 46.5 mm. (Column 5L)

A'B'C', Measurements of Skull 14. (The minimum angle)
- Angle *B'A'C'* = 13 degrees (Column 6L)
- Distance *B'C'* = 23 mm. (Column 2L)
- Distance *DE'* = 11 mm. (Column 3L)
- Distance *E'C'* = 56 mm. (Column 5L)

A"B"C", Measurements of Skull 11. (The maximum angle)
- Angle *B"A"C"* = 26 degrees (Column 6L)
- Distance *B"C"* = 28 mm. (Column 2L)
- Distance *DE"* = 8 mm. (Column 3L)
- Distance *E"C"* = 46 mm. (Column 5L)

*The angle formed by the intersection of the plane of occlusion by Cook's plane.

OCCLUSAL PLANE PROJECTOR

The occlusal plane projector was constructed which would incorporate these basic relationships. It was made to accommodate the variable relationships which have been described. Its construction was based on the theorem of the projection of a line when the arm of an angle and the angle itself are known (Fig. 4). Dentulous casts were first tested with the plane projector. Each cast was fixed in the

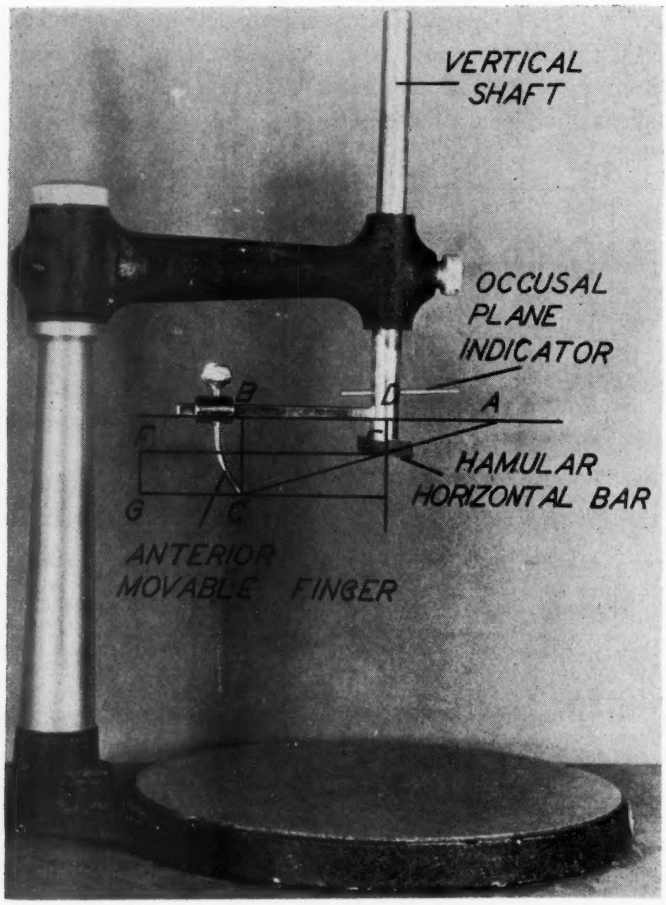

Fig. 4.—The occlusal plane projector.

cast holder, and positioned so the anterior movable finger touched the mucco-labial fold adjacent to the frenum, and so the hamular horizontal bar rested in the two hamular notches. The cast was held tightly together with the plane projector, and they were lowered until the cast holder flattened itself against the surveyor base. The universal lock of the cast holder was then tightened (Fig. 5). The occlusal plane indicator was positioned to the height of the central

incisor teeth (Fig. 6). With the occlusal plane indicator locked at the height of the central incisors, the cast was rotated around it. It was found that the incisal plane indicator pointed to the height of the buccal cusps, with only minor variations. Those variations, for the most part, were attributable to either the curve of Spee or to the shifting of teeth due to the loss of adjacent or opposing teeth (Figs. 7 to 9).

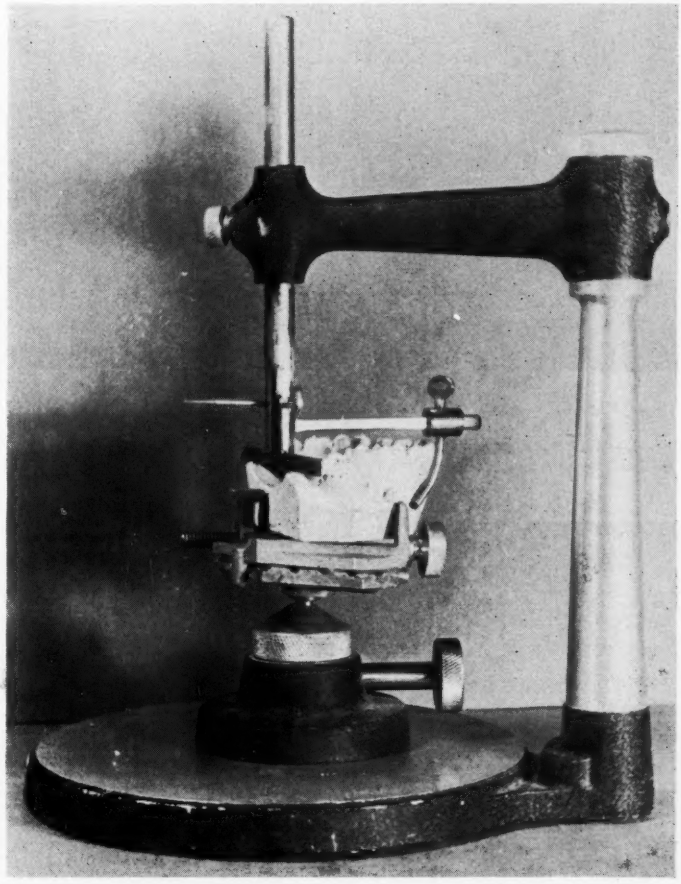

Fig. 5.—A dentulous cast locked in position on the occlusal plane projector. Note the position of the hamular horizontal rod and the anterior movable finger.

Edentulous casts were then subjected to the same determination (Fig. 10). Since there were no anterior teeth to act as a guide to the height of the plane of occlusion on edentulous casts, a lip calibrator was fashioned (Fig. 11). The purpose of the lip calibrator is to establish the proposed height of the anterior teeth on the denture. The lip calibrator is provided with a single tooth and a millimeter scale to aid in the esthetic orientation of the anterior aspect of the plane of occlusion. The lip calibrator was inserted into the anterior muccolabial fold to its furthermost limits, straddling the labial frenum. The proposed height

of the plane of occlusion was measured with the tooth and the lip length as guides. That measurement was then used to determine the height of the plane of occlusion and was used with the occlusal plane indicator (Fig. 12).

When the height of the occlusion rim was trimmed to coincide with the plane scriber, it was found that: (1) These bite rims when tried in the mouth required much less modification at the chair than occlusion rims otherwise con-

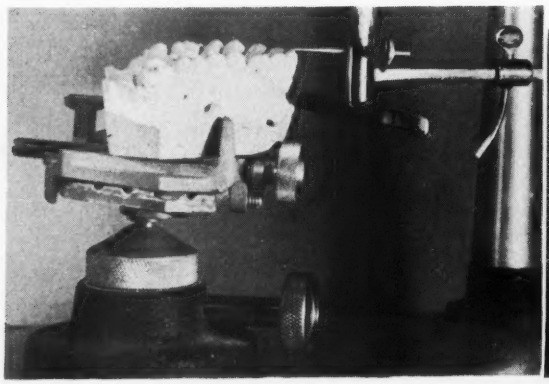

Fig. 6.

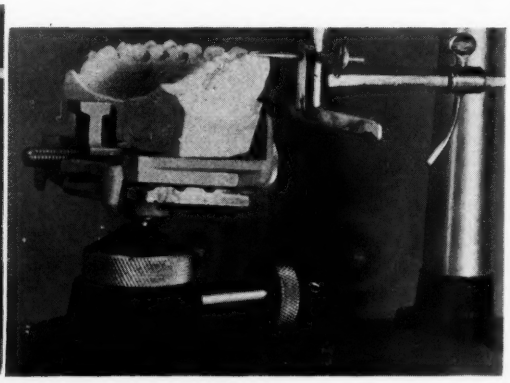

Fig. 7.

Fig. 6.—The occlusal plane indicator adjusted to the central incisor teeth.
Fig. 7.—The cast is rotated to show the relative height of the cuspid tooth.

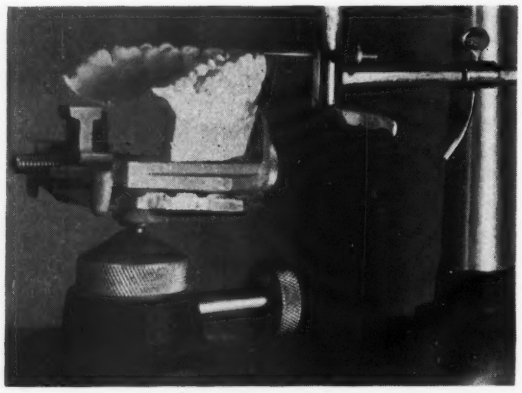

Fig. 8.

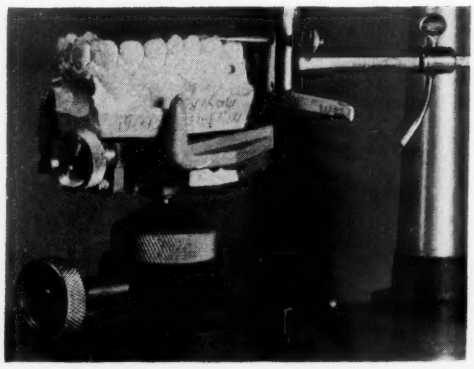

Fig. 9.

Fig. 8.—The cast is rotated to show the relative height of the buccal cusps of the bicuspid teeth.
Fig. 9.—The cast is rotated to show the relation of the occlusal plane indicator to the buccal cusps of the molar teeth.

structed. (2) The confusion arising from inconsistencies in ridge height was minimized. (3) It was easier to deal with the many related problems of setup and articulation since this procedure provided an excellent guide for the orientation of the plane of occlusion.

It is recommended that the occlusal portion of the occlusion rim be constructed with three laminated layers of wax. In the event it is necessary to raise

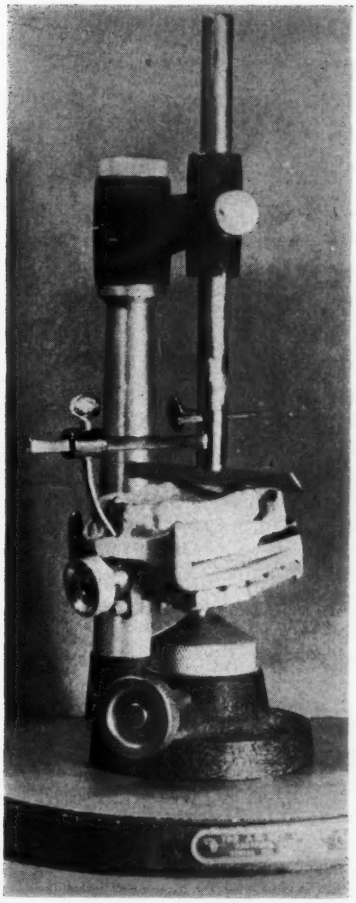

Fig. 10.—An edentulous cast in position on the occlusal plane projector.

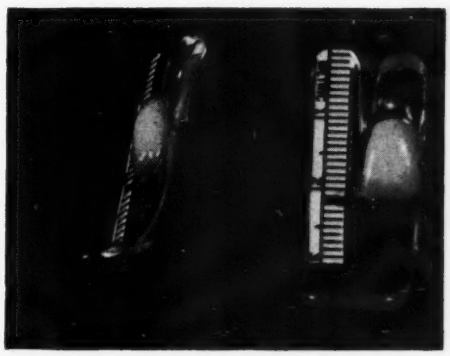

Fig. 11.—The lip calibrator.

the height of the occlusal plane, it can be done evenly by stripping off a millimeter of wax at a time. (Fig. 12.)

The occlusal plane projector can be adjusted to the individual variations inherent in each cast. The finger indicating the anterior nasal spine can be accommodated to the variable distances between the hamular notches and the anterior nasal spine on various casts. The angle formed by Cook's plane and the plane of occlusion will be varied accordingly.

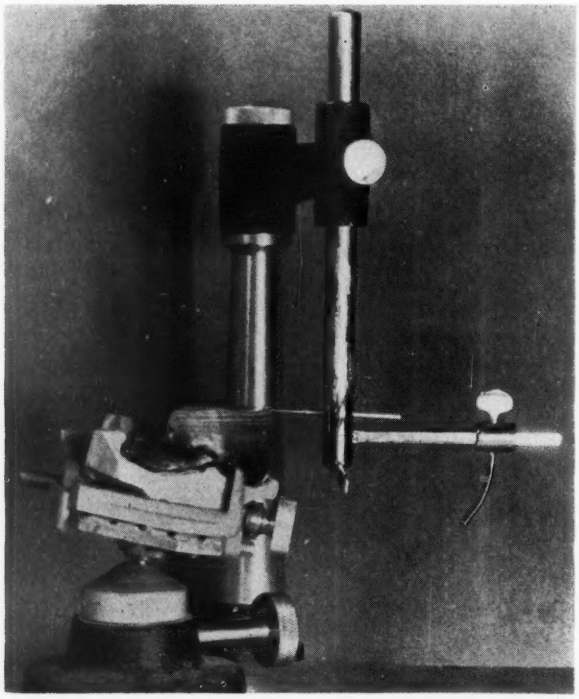

Fig. 12.—The occlusal plane being scribed upon an occlusion rim.

Since the degree of divergence or the minimal difference in parallelism between the plane of occlusion as determined by a line from the tip of the lower cuspid to the crest of the distobuccal cusp of the second molar, and the plane of occlusion as determined by projecting a tangent to the curve of Spee at the mesiobuccal cusp of the first molar, is so slight this might be considered as an alterate method of determining the plane of occlusion.

SUMMARY

1. Cook's plane forms an angle with the plane of occlusion which falls within predictable limits.

2. The angle formed by Cook's plane and the plane of occlusion is related to the distance from the anterior nasal spine to the hamular notch. The greater

the distance, the more acute the angle; the shorter the distance, the more obtuse the angle.

3. Though there is a certain bilateral asymmetry in the skulls and casts measured, it is negligible in its effect on the basic correlations.

4. Though the distances from the anterior nasal spine and the hamular notches to the plane of occlusion varied, the difference between the two measurements approached a constant, enough to permit the practical use of the average value.

5. Within esthetic considerations, the anterior aspect of the plane of occlusion should be kept parallel to the pupils of the eyes.

CONCLUSION

There is apparently a relationship between fixed cranial landmarks that are common to both the skull and the edentulous upper cast. This relationship is sufficiently constant to allow the projection of the plane of occlusion when certain fundamental individual adjustments are incorporated into a mechanical device that correlates these basic relationships.

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PREPARATION OF THE MOUTH AND CASTS FOR IMMEDIATE DENTURES

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MANY essays have been written on the subject of preparing the mouth for immediate dentures; however, the preparation of the casts is as important as the preparation of the mouth. Preparing the casts is the duty of the dentist whose visual and digital examination can be transferred to the cast with the better skill of observation than the technician, who merely sees the abstract in the stone cast. The logic of this is most evident because of the complexities and exacting phases of artificial denture service. The prosthodontist, upon examination of the mouth, will look for abnormalities, pathologic conditions, and the many other factors, favorable or unfavorable, that become apparent through experience to the practicing operator. After a complete case history and patient analysis, recording of pre-extraction records, radiographic interpretation and prognosis, the posterior teeth are removed and trimming is done only for the necessary alveolar contour to ready the patient for the future immediate dentures. All excessive gingival structures and pendulous soft tissues should be trimmed away, for flexible gum tissues are poor denture bases. The cuspids, and occasionally the first bicuspids, are maintained in order to retain the vertical dimension and the key to occlusion, and also in order to allow the necessary esthetics for the recuperation (four to six weeks) of the posterior edentulous areas.

CLASSIFICATION

For explanatory purposes the normal and the common anatomic abnormal difficulties of the mouth relative to immediate denture insertion will be classified as follows: (1) hard tissues, (2) soft tissues, (3) ridge relation. No detailed surgical procedures will be discussed, for the subject is treated from a purely prosthetic standpoint. Consideration of pathologic conditions, roentgenographic examination, unerupted teeth, infection, cysts, root removal, extraction of the teeth, etc., will be accepted as common knowledge of the competent oral surgeon. Under each classification the preparations on the casts will be explained.

HARD TISSUES

1. *Bony Protuberances (Exostoses).*—

A. A Torus Palatinus (Fig. 1) in most cases requires no preparation of the mouth but, if extremely large or severely pedunculated, sugical *reduction* is re-

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quired and is not difficult. Extensive reduction or entire removal of the bony hypertrophy is not of benefit and is most painful and may be harmful to the patient.

Treatment on the Cast: (1) Any area (torus or hard rugae) under the denture base that may act as a fulcrum which in turn will cause the denture to have lever action, to teeter or fracture, should be given adequate relief. Care should be taken not to extend the relief so far posteriorly as to interfere with the post dam area. (2) The procedure of avoiding the coverage of this bony elevation by cutting out the palatal section of the denture and the roofless or "horseshoe" type is occasionally successful. (See Post Dam and Palatal Seal.) (3) The practice of gradually relieving the hard areas as the denture settles should also be considered. With this thought in mind, the palatal portion of the acrylic base is made extra thick. (4) The construction of a cast metal palatal base or a swaged metal base, relieving the torus slightly with air chamber metal (No. 21) to allow for the initial denture settling, affords another approach to this problem. A swaged metal palatal base will have an advantage, in some cases, because it can be reswaged when mouth changes occur.

Fig. 1.—A torus palatinus which occupies almost the entire palatal vault.

Bone readily changes under pressure; the metal base will cause some reduction by resorption of this torus, the resultant of time and pressure as the denture settles. This phenomenon is well illustrated in Figs. 2 and 3.

B. Torus Mandibularis or Lingualis (Fig. 4), if extensive, requires surgical intervention and is simple to perform. Surgical intervention is not necessary if they are small and flat, but mucosa over these areas being thin and unyieldingly tense requires relief.

Treatment on the Cast: If the torus mandibularis is to be removed, the cast is scraped to conform with the surgery. If small and no surgical reduction is necessary, relieve with lead foil, but do not extend the relief so as to break the peripheral seal of the denture at the lingual flange.

C. Sharp Spines (Spiculae) are the greatest cause of denture pain, for "every bite is dynamite." These should, in all cases, be surgically removed, preferably at the occasion of the necessary extractions. An aid to the elimination of spiculae is the trimming of the alveolar septa at the time of extraction, and a

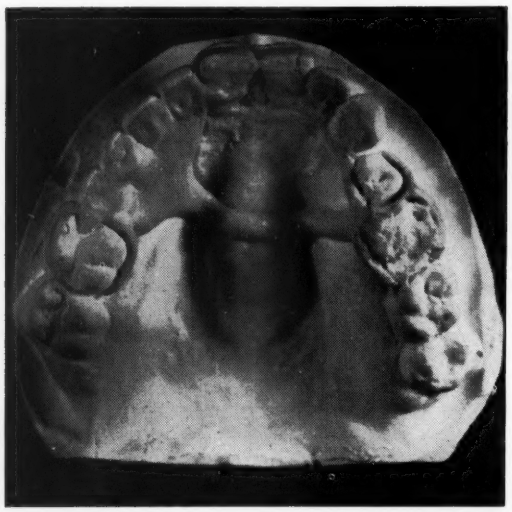

Fig. 2.—An upper cast gold palatal bar denture built over a prominent torus palatinus. At the time of insertion, the palatal bar did not contact the torus.

Fig. 3.—The reduction of part of the torus due to bone changes caused by pressure in less than three years. (See Fig. 2.)

thorough clean-up of tooth and bone chips. Their removal is a *must* even after completion of the dentures, and the denture should be relined in that area with direct bench curing acrylic. Some small sharp spicules of the process can be eliminated by placing a butt-end instrument firmly over the area and giving a

sharp hard tap with a metal mallet. The crudeness of this action can be justified only by its miraculous result.

Treatment on the Cast: No aid can be accomplished.

D. Mylohyoid Ridges.—We are concerned only with that prominent short part of the internal oblique line which is situated between the attachment of the pterygomandibular raphé and the fossa for the submaxillary gland. The mylohyoid muscle attaches to the under surface of this ridge and joining with its fellow of the opposite side forms the floor of the mouth. The fibers of the muscle run downward and medially; hence, within functional limits, the muscle attachments are not a denture displacing factor. The bony ridge should be surgically removed at the time of the posterior extractions, in cases of interfering convexities.

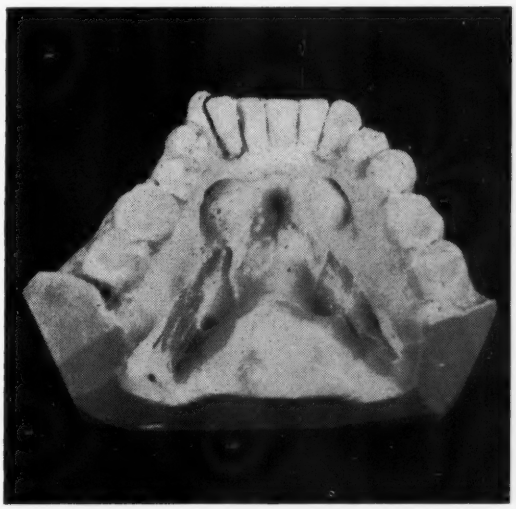

Fig. 4.—Torus mandibularis. The severity warrants surgical removal to avoid serious interference with prosthetic restorations.

The reduction of this part of the ridge undercut will allow perfect adaptation to the lingual slope of the ridge and permit the periphery of the lingual flange to have continual contact within the functional limits with the soft tissues of the floor of the mouth at the lingual ridge base. This will aid in preventing the soft tissues of the floor of the mouth from being pinched under the denture in this area.

Treatment on the Cast: When the patient absolutely refuses surgical corrections: (1) Scraping this posterior protuberance of the mylohyoid ridge, thus deliberately placing pressure on it and causing it to resorb. Bone is readily changed by pressure, and consequent exfoliation or resorption of its cortical plate and keratinization of its tightly attached tissue will aid in carrying denture stresses, provided there is equalization by proper occlusion. (See Fig. 5.) Most lower dentures will go to place with a backward-to-forward placement. Denture pressure applied to the hard cortical plate will cause some resulting pain; however, it will not be intense or enduring, and this sharp spinelike part of the internal oblique ridge will exfoliate or resorb and relieve itself under the pressure of the denture

base. (2) Place tinfoil relief over the shinbonelike ridge, thus avoiding pressure on this spiny process. Do not extend this relief to the functional limits of the lingual flanges in relation to the tissues of the floor of the mouth. To extend it there would break the peripheral seal of the denture base.

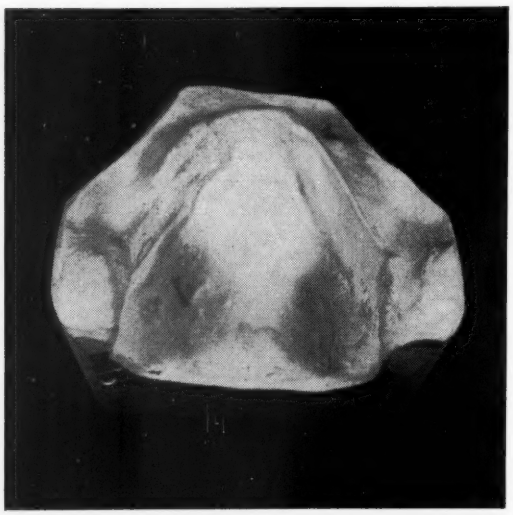

Fig. 5.—A spiculated protuberance of the sharp spinelike posterior end of the mylohyoid ridge on the left side.

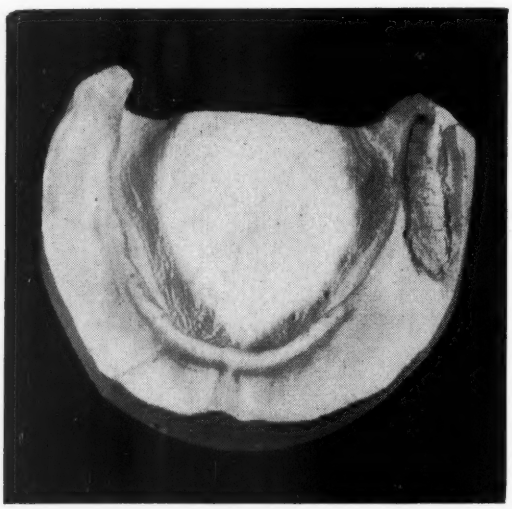

Fig. 6.—A knife-edged ridge.

E. Knife-edge Ridges.—One of the cardinal purposes of the immediate denture is to produce well-rounded ridges: This is a salient factor in the prevention of the knife-edge ridge. Nature rapidly resorbs to a knife-edge an alveolar ridge that is not covered and controlled with dentures (Fig. 6).

Surgical intervention in some cases may be necessary, but the involvement then becomes more complicated. With the reduction of the sharp edged ridges enter the problems of shallowing the mucobuccal and mucolabial folds or sulci and the floor of the mouth, and of increasing the height of all frenula and muscle attachments. These muscle attachments in turn must be operated upon, dissecting them from the remaining shallow ridge. Also, the master problem of some form of proper tissue suturing or retainer or splint must be provided. When difficult cases present themselves, the patients should be impressed in advance of denture expectations and limitations.

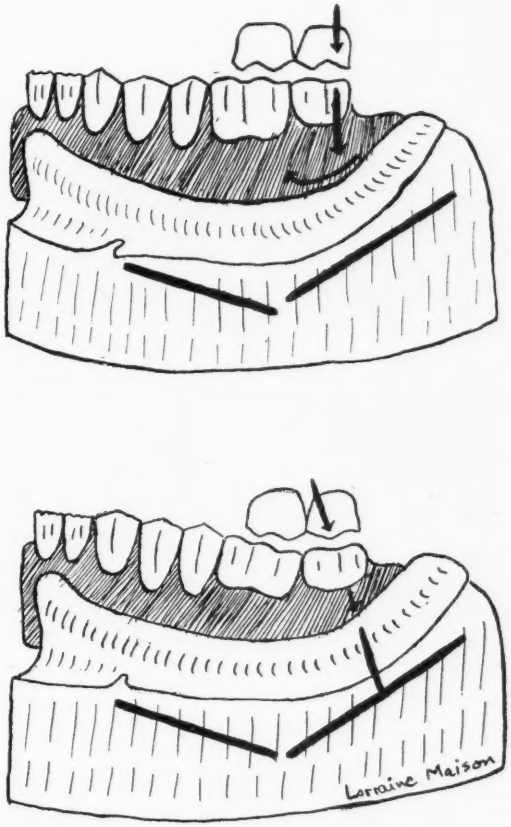

Fig. 7.—*Above,* "The line of force against the masticatory surface of the second molar is not perpendicular to the ridge, and hence will have a tendency to cause the denture to shift forward. *Below,* The correct position of the masticatory surface, with the line of force perpendicular to the ridge. This method suits each individual case. Whereas, the Wadsworth method of establishing the curve of Spee is illogical because of the fact that very often its direction must be changed arbitarily to avoid cutting the distal end of the cast." (After Gysi.)

Treatment on the Cast: (1) Radical surgery is not the answer to knife-edge ridges. The problem can be only partially solved by the use of shallow modified cusps and a small mold of posterior teeth, thus forming a narrow occlusal table. Cuspless or well-milled teeth will eliminate soreness which is due to torque, and increase the shearing action of mastication. The teeth should be set toward

the lingual side of the ridges to direct the occlusal load within the arches, and toward the center of the denture foundation, but the possibility of displacement by the tongue should be avoided. The occlusal surfaces of the teeth (the occlusal balance) should be set to conform parallel to any curve or slope of the mandibular ridge, thus allowing the force of mastication to be received perpendicularly upon the ridge curvature or interalveolar crest line. This produces favorable leverage from within the arches in order to better seat the denture, rather than to allow it to teeter on the knife-edge ridges. Lines are drawn on the cast parallel to the ridges as a guide for setting the teeth at this proper angle (Fig. 7). (2) Relief of the knife-edge ridge can be provided by placing lead foil on the cast at the crest of the sharp spine, thus removing occlusal pressure at this area, and allowing the force to bear on the slopes of the ridges. The use of an elastic or soft resin or acrylic in these cases meets with the same failure as the use of velum rubber in the past.

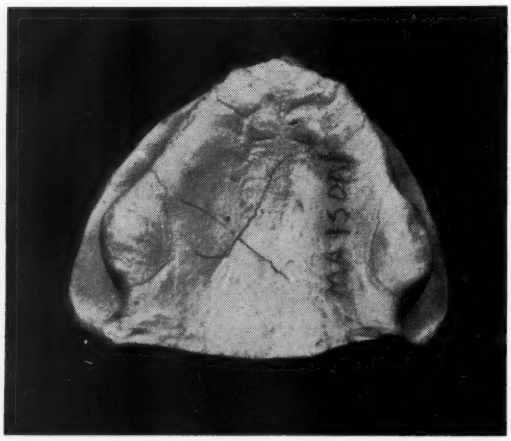

Fig. 8.—Bulbous tuberosities. Time spent in diagnosis and prognosis will avoid that embarrassing predicament of not being able to place the denture in the mouth after it is completed.

F. Maxillary Tuberosities.—These may be divided into three classes: (1) the bulbous type, (2) low-hanging tuberosities, (3) the tuberosity that is a monstrosity. This third classification is seldom seen in practice, but is always well illustrated in textbooks. Of course surgery is indicated, if possible.

(1) The bulbous type creates undesirable undercuts (Fig. 8), endangering adequate peripheral seal at the soft areolar tissue, and will not allow the completed denture to pass over the prominent bony buccal protrusion. Surgical removal of this severe bony protuberance responsible for the undercut is unavoidable in most cases. However, in many cases, it may be wise to trim only the tuberosity or interfering ridge convexity of one side; thus, the denture can be "hooked" into the undercut of the opposite side. Moderate undercuts or mechanical locks often are retentive aids to the denture bases.

Treatment on the Cast: As this operation is usually accomplished before the master impression is made, no preparation is necessary on the cast. If the operation follows the impression, the cast is so scraped as to relieve any undesirable undercuts.

Determining the shape and contour of the ridges by the use of a clear acrylic surgical template (constructed over the previously trimmed cast) has been tried and found wanting to both the surgeon and the prosthodontist. The mere blanching of the tissues, as shown through the clear acrylic base, does not indicate surgical intervention because some tolerance of the denture base *must* be anticipated.

(2) Low-hanging tuberosities cause an abnormal ridge relation due to the lack of space between the tuberosities of the maxilla and the retromolar pads (Fig. 9). This insufficiency of clearance should be corrected at the same time that the posterior teeth are removed. This can ordinarily be accomplished by an

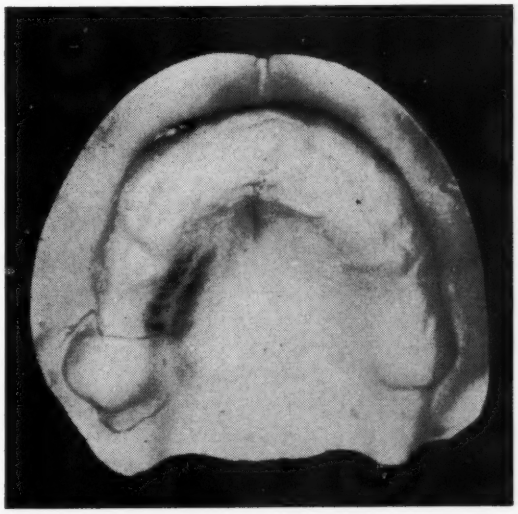

Fig. 9.—A low-hanging tuberosity which will produce a lack of intermaxillary space.

elliptical incision through the thick fibrous pad to the periosteum, removing a triangular section of the necessary amount of fibrocartilaginous tissue, without the removal of any bone tissue in most cases. Some cases require the removal of some bone tissue. All excessive lengths of the flaps are trimmed away, and the edges of the area are sutured strongly together. The mere superficial excision of the excessive tissue will be of no value, and the resulting mass of scar tissue will be as objectionable as the original tuberosity.

Any attempt to gain clearance by intervention of the retromolar area of the mandible is to be condemned, for the retention of the full lower denture is most dependent upon the retromolar pad. The very reason for obtaining this clearance is to avoid underextension of the denture bases; let us not mutilate our most retentive areas.

Treatment on the Cast: The distal ends of the cast are scraped to allow for the denture base clearance. If some space exists in this area, thin strips of stain-

less steel (which are less expensive and less difficult than castings) may be inserted in the dentures, thus allowing clearance at the distal end of the denture. Any abnormal opening of the vertical dimension for immediate dentures is not advisable. Never open the vertical dimension on the articulator, as this eliminates the free-way space, and may cause clicking of the denture teeth. In all cases, a duplicate cast is made from the completely altered master cast after the boiling out procedures of flasking. This is to be referred to at the time of surgery.

G. Alveolar Contour.—At the same time that the posterior teeth are removed, all necessary alveolar contouring should be performed. This should be confined to a slight smoothing of all rough, sharp, or jagged margins, and the trimming of the alveolar septums of the processes, and the removal of all excessive gingival tissues. This brings up the controversy as to the amount of bone trimming to be done. At this point, let us divide all operations whether they be alveoloplasty, alveolectomy, or alveolotomy, etc., into two groups: (1) operations of necessity, and (2) operations of election.

Fig. 10.—Labial undercuts. The high lip line is a "must" consideration. A thorough diagnosis and prognosis must be made to avoid thin knife ridges before radical surgery is attempted.

The patient must rely upon the conservation of the alveolar ridges for denture success. Surgical procedure should be confined to such operations of necessity as the roentgenographic examination may indicate, or to those for the improvement of the topography of the bone and soft tissues. In operations of election, ridges can be ruined because of overenthusiastic bone removal. No more osseous structure should be removed than is absolutely essential, bearing in mind that "resorption is an inevitable sequence."

If there are some minor irregularities, the very presence of immediate dentures will produce well-rounded alveolar ridges with less bone resorption. There is reason to believe that changes of the residual alveolar bone are entirely mechanical, and the performance by the immediate denture will avoid knife-edge ridges and maintain the muscle tone of the cheeks and lips. The matrixlike action establishes

a firm blood clot which is an aid in the development of new bone. Always beware of "the perfect" denture mouth, for most every dentist has met a denture failure at least once with "the ideal case."

The anterior region of the maxilla may present an unfavorable undercut (Fig. 10) so the denture cannot be inserted. The area may have to be trimmed in cases of extreme vertical or horizontal overlap to correct minor faulty ridge relations for esthetics. This region is trimmed at the same time as the remaining anterior teeth are removed. Bone contouring must be conservative. Excessive removal of the labial plate may drastically change the facial expression. Some cases indicate that the immediate denture be made by butting the anterior denture teeth, and omitting the labial flange, for often within a short time sufficient resorption of the labial plate will occur to eliminate the undercuts.

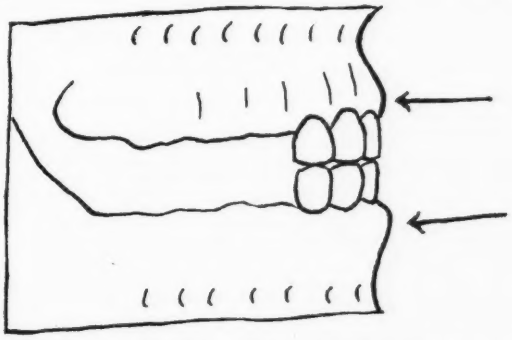

Fig. 11.—Arrows indicate the gingival crest. Any trimming of the cast above the crest in the upper, and below the crest in the lower will produce unfavorable undercuts.

Trimming the labial surface of the bone should be limited to the minimum. Many cases simply require extraction and a slight smoothing of the process. In some cases, a labial undercut may allow the denture to slide into it and be an aid to retention. After the immediate denture is worn for some time, this area will undergo a considerable change in form, and the muscles of the upper lip will become more flexible. Consequently, when a secondary denture is constructed all the complex problems will have disappeared.

Treatment on the Cast: The labial surface is trimmed but slightly in ordinary cases. Most of the trimming is done at the gingival crest. Any trimming below the gingival crest will produce an unfavorable undercut at the periphery of the denture and it will not go to place. (See Fig. 11.) In cases with periodontal pockets and very cancellous bone, visual observation correlated with roentgenographic interpretation will be the determining factor as to the depth to which the cast is to be trimmed. To protect the peripheral seal at the labial flange of the denture, the cast may be scraped lightly (approximately ½ mm.), according to the flexibility of the tissue, at the incisive fossa on both sides of the labial frenum. (See line *A*, Fig. 12.) This aids in preventing the denture seal from breaking at the labial frenum. The cast (upper or lower) should receive relief over the cuspid eminences on both sides to avoid the familiar pincer action in these areas as the immediate dentures are worn.

The inner or palatal side of all immediate dentures should be smooth, with a well-rounded concave form, serving as a matrix for the formation of well-rounded edentulous ridges as they heal. The presence of projections into tooth sockets interferes with healing, and promotes resorption because of pressure upon the bone.

SOFT TISSUES

A. Abnormal Frenula and Ligament and Muscle Attachments.—Frenum attachments are located not only at the median line or in the cuspid-bicuspid region, but also may be found at any locale of the denture's periphery. A review of the literature shows that there has always been considerable controversy as to the necessity of surgical displacement of these low muscle or tissue attachments. Promiscuous surgical intervention should surely be frowned upon. For example, excessive removal of the labial frenum permits the upper lip to curl unattractively. However, since the operation in most cases is simple with few failures and with gratifying results, it may be performed to better serve denture construction and function. Simple frenula can be "snipped" with surgical scissors, lancet, electrocautery, or actual cautery with more accuracy after the dentures have been worn a few days.

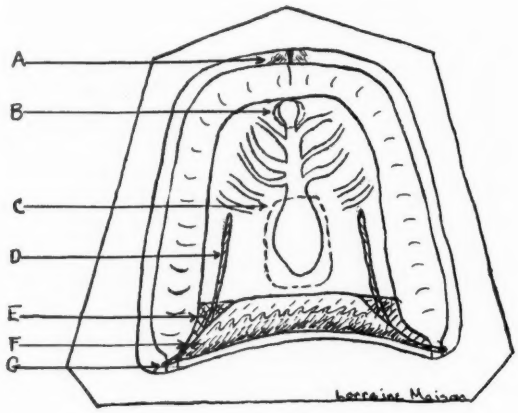

Fig. 12.—*A*, Scraping the cast in the incisive fossa at both sides of the labial frenum aids in preventing a break in the denture seal. *B*, Pressure relief over the incisive foramen. *C*, Relief of the median suture may be necessary, if it is prominent, otherwise it may be omitted. *D*, The palatal seal varies in *all* cases according to tissue displaceability. *E*, Scraping of the cast to compensate for dimensional changes occurring during the curing of the acrylic base. (See Fig. 13, *F*.) Wide valve sealing of the displaceable post dam area. *G*, The most posterior end of the unmoving but displaceable soft palate (the vibrating line).

The superior attachment of the pterygomandibular raphé may be so abnormal as to obliterate the maxillary tuberosity. This ridge of tissue then hinders denture retention by causing a break in the continuity of the peripheral seal. It prevents the complete seating of the denture, and affords no protuberance of the tuberosity as a part of the denture-bearing area. It prevents adequate posterior extension of the denture.

There are some tensionless frenal tissues, ligaments, muscle attachments, etc., that can be stretched by the splinting action of immediate dentures. This is one of the foremost purposes of primary dentures. Certain stresses and strains upon tissues will not be tolerated under some conditions; under other circumstances they may be borne with no hindrance, and the patient will register no complaint. Digital and visual examination will be a direct guide in the determination of the physiologic limits of tolerance. Thus a planned displacement of tissue can be anticipated without a detrimental effect upon denture functions and tissue health.

Treatment on the Cast: The above conditions are relieved by cutting to modify the obstructions on the cast, for either the immediate or postsurgical method, or that of tolerance.

B. Soft Flabby Tissue; Spongy Mucosa—Hypertrophied Tissue.—Investigation of the basic cause of this abnormality is of more importance than the treatment of the effects. Prevention and control are better than the cure. Frequently the anterior region of the upper arch becomes swollen and spongy because of trauma. This is due to heavy occlusal stress brought about by resorption and loss of vertical dimension. The use of plastic upper anterior teeth, which occlude with porcelain lower anterior teeth, and with a full complement of posterior porcelain teeth will minimize the trauma of occlusal stress in the anterior portion of both arches. The lower anterior porcelain teeth will wear upon the upper anterior acrylic teeth or denture base so the occlusal pressure in this area will be reduced and will allow the stress to remain in the bicuspid and molar regions.

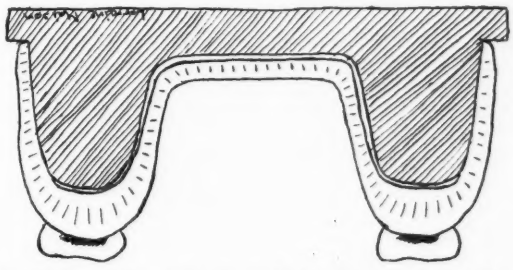

Fig. 13.—The space between the denture and the cast produced by the shrinkage of the acrylic base materials during curing.

The elasticity of this creeping spongelike tissue, which is constantly yielding and changing its shape under chewing pressure, seriously interferes with the stabilization and efficiency of dentures. Therefore, these hyperplastic tissues must be (1) removed surgically, (2) controlled, or (3) prevented.

The surgical removal of this soft mass should be complete to the bone. The hyperplastic tissue should be dissected out in an elliptical shape over the ridge crest so as not to shorten the mucolabial or mucobuccal fold. To aid in the prevention of this condition at the time of tooth extraction, all excessive overhanging and interseptal gingival tissues and overlapping edges of incisions should be well-trimmed away and properly sutured.

There are cases in which constant irritation of long standing, by ill-fitting dentures, has produced such abundant tissue proliferation over the entire oral cavity

that surgical intervention would be just too extensive and destructive. In such cases, the only remedy is to have the patient refrain from wearing the dentures. With the removal of the causes, the tissues will return to normal in a reasonable amount of time. However, the correction of this abnormality may require some preparatory surgery.

It is self-evident that general systemic conditions of the patient's health play a most important role. Many diseases, deficiencies, nutritional disturbances, endocrine imbalances, and dietary insufficiencies project themselves upon the screen of the oral mucosa and underlying bone. Observant care of the problem of ration with regard to vitamins, minerals, and bone meals will aid greatly in the control and prevention of hypertrophic tissues.

Treatment on the Cast: Flabby ridges are the results of increased functional demands or work hypertrophy. The use of a small mold of low cusp teeth (noninterlocking) and, in some cases, plastic teeth will lessen the stress of occlusion over these areas. The anterior teeth should never be set in contact or so they will interfere with functional movements. Ample free-way space in the denture setup will also aid in the prevention of flabby ridges by allowing noncontact of the occlusion when the jaws are in rest position, repose, or during speech.

The impression technique should be such that there will be the minimum dislodgement of hyperplastic tissue by pressure which would cause the denture to rebound, and pinch or draw the tissue under its base.

When recording jaw relations in flabby ridge cases, beware of producing the harmful effects of occlusal pressure upon flabby tissues. The use of very soft equalizing wax under the occlusion rims (allowing about five minutes for the wax to flow with the body temperature), and over the occlusion rims will help to relieve excessive pressure.

RIDGE RELATION

A. Faulty Ridge Relationship.—Prognathous (protruded) and orthognathous (retruded) mandibles or conditions of acromegaly, etc., will not be discussed in this paper, as their correction lies in the field of oral surgery. Immediate dentures are contraindicated for patients with extreme malrelation of the ridges. However, there should be always a close relationship between the oral surgeon and the prosthodontist, for the end results will be in the hands of the latter.

Some cases of minor improper relationship of the arches can be aided by the use of cuspless or mechanical teeth which eliminate intercusp relationships, and allow a gliding and shearing action of the occlusion or food table. The use of plastic teeth will, in many cases, allow better esthetics in the anterior region than porcelain teeth that rely on pins for retention to the denture base. They can be of a shorter mold and can be reduced further at the ridge lap.

B. Obtaining Jaw Relationship.—The vertical opening and centric relation records are made by using the old-fashioned "mush-bite" technique. Very soft wax (plastic wax), which can be molded into the form of oblong cakes at ordinary room temperature, is placed over the posterior areas of the upper ridges. The

size of the wax cakes depends upon that of the intermaxillary space. They may be placed bilaterally or unilaterally. Care must be taken to avoid placing any wax on the remaining anterior teeth so as to cause an increase in the vertical dimension. The patient is instructed to occlude slowly the anterior teeth to their normal occlusion. Three to five minutes are allowed for the wax to flow. The flow can be judged by observing the blanching of the tissues due to the pressure of the wax and the color of the tissues as they return to normal. The wax record is checked to be sure of its correctness by comparison with previous observations and markings on the remaining anterior teeth when they were in proper contact. The wax must be thoroughly chilled before it is removed. *Note:* Do not "blindly" accept the correctness of the occlusion of the remaining natural teeth for determining centric relation. They may be in malocclusion and may require spot-grinding, or, in a very few cases, a temporary increase in the interalveolar space.

The advantage of this method is that when the casts are mounted on the articulator the anterior teeth will not be held apart. The very softness of the recording wax will not allow the patient to exert any objectionable pressure, and the tissues of the ridges will be displaced to the minimum. There will be no stretching nor pull upon the muscles of mastication, nor displacement of the condyles.

It is just as important to obtain the jaw relationship as it is to make the impressions with the minimum displacement of tissue. A try-in of the posterior teeth gives the final check-up of the occlusion. Be sure to test the wax set-up for any possible movement when in biting stress between the ridges and the wax bases. This is a *must* in immediate dentures, for the time given to this step may save a lot of time and trouble later.

POST DAM AND PALATAL SEAL

With slight variations, the post dam and palatal seal are practically the same for the horseshoe denture, and for avoiding of the torus as in the full upper denture.

A. The Post Dam.—The throat contour is examined by digital exploration and visually by having the patient flex the soft palate, thus locating the most posterior line of the unmoving displaceable soft palate (vibrating line). This line is drawn with an indelible pencil and extended through the hamular notches on both sides to mark the posterior extension of the denture. The soft areolar tissue in the hamular notches is easily displaceable and provides an ideal posterior palatal seal. Do not be misled that the denture cannot be extended posteriorly beyond the foveola palatini. (See line *G* in Fig. 12.)

The anterior limit of the post dam is placed in the soft tissue immediately back of the hard area of the median raphé in the vault of the hard palate. This also is charted with an indelible pencil.

B. The Palatal Seal.—By digital palpation (using a ball-pointed instrument), the soft tissue which lies on either side of the palate between the hard palate and the base of the ridge, the area of most displaceability is located, and marked

in the lateral wall of the palatal vault with an indelible pencil. This marking is done from the posterior toward the anterior, starting within the post dam along the side of the palate and stopping short of the hard rugae area. (See line *D*, Fig. 12.) In horseshoe or roofless dentures, or in dentures avoiding the torus palatinus, the palatal seal becomes the peripheral seal. It is placed along the displaceable tissue area close to the torus. However, the denture periphery is made thick to allow for trimming when settling occurs. It is also extended onto the thicker mucosa of the hard area of the palate. If the periphery ends in the soft tissue of the palate, the soft tissue will hypertrophy.

After these markings are made, the impression is made with the minimum of tissue displacement. The indelible lines are transferred to the impression, and in turn to the cast.

Treatment on the Cast: All the necessary relief, scraping, palatal seal, and post damming are done upon the cast, not upon the impression. The cast is scored at the posterior line of the post dam with a sharp instrument to the depth of about 1½ mm., depending upon the displaceability of the tissue. The palatal vault then is scraped in a gradual slope from the posterior line to a feather edge at the anterior line of the post dam. This will produce a long valve seal, not a sharp bead that will cut into the soft palate, and will allow for trimming without danger of loosening the palatal seal. (See line *F* of Fig. 12.) There are cases that have a prominent and hard median suture which require a bit less scraping at this median spine.

When scraping the cast for post damming, always bear in mind and allow for the dimensional changes in the denture base due to shrinkage of the base material. The changes vary with the bulk of the material, and amount to approximately ½ to 1 mm. During curing, the acrylic base shrinks away from the palatal portion of the cast between the center of the hard palate and the crest of the ridge, and later expands due to the absorption of moisture (Fig. 13).

The Palatal Seal: The palatal seal is produced by carving grooves in the cast along the previously marked indelible lines. These are about 2 mm. in width and 1 mm. in depth according to the tissue displaceability. (See line *D*, Fig. 12.) A Frahm carving instrument works very well for carving these grooves and the posterior line of the post dam. Shrinkage of the base material also occurs in the lower denture. To counteract this shrinkage the lower cast is scraped about ½ to 1 mm. in proportion to the bulk of base material in the posterior lingual flange beneath the retromolar pad. This maintains a long valve seal and closer adaptation of the denture flange to the lingual slope of the ridge surface of the tissues.

RELIEFS

To prevent the denture from rocking under biting stress, the necessary relief should be placed over the prominent median suture of the maxilla. (See line *C*, Fig. 12.) The size and amount of relief will vary with the size and hardness of the area in the mouth. The relief is made by adding a thickness of lead plate to the cast. The incisive foramen located at the most anterior part of the median

suture in the rugae area must receive relief. Pressure at this point may cause burning sensations under the denture due to interference with the nerve and blood supply. (See line *B*, Fig. 12.) The tightly attached tissue of the rugae area can withstand denture pressure and should not be relieved. It is axiomatic that the indiscriminate placing of relief in dentures reduces their retention and lessens and ill-distributes their stress-bearing surfaces. The palatal vault with its lateral and anterior walls form a denture-bearing area that is least subject to changes and most capable of carrying the denture load.

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FORCE ANALYSIS OF PROSTHETIC APPLIANCES DURING FUNCTION

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THE FIRST attempts to measure or estimate forces used during chewing were carried out by Black in 1895.[1] He studied a series of foods in vitro by means of an instrument called a phagodynamometer which crushed foods with a straight hinge motion. The forces required ranged from 20 to 80 pounds. In 1906 Head[2] developed an extra oral instrument in which trituration or shearing was obtained. By this means, he demonstrated that considerably lower forces were required in food pulverization. Klatsky[3] had persons express what they considered to be an average "chewing force" on a gnathodynamometer and found that the forces used "during mastication" were about one-fourth of the maximum biting forces the patients could exert. In 1950 Howell and Brudevold[4] devised a method whereby forces could be measured directly in the oral cavity. The results of these studies indicated that the forces actually used by a full denture wearer during mastication of foods were considerably lower than would be expected from previous literature.

Since Brudevold's studies were limited to one denture wearer and forces were not obtained simultaneously on all three teeth studied, this investigation was designed to supplement his study, and to include other prosthetic situations. Some modifications have been made in his technique which resulted in greater stability and duplication of results.

EXPERIMENTAL PROCEDURES

The apparatus consisted of a variable-inductance strain gauge which was incorporated into an artificial tooth to form a bite element. One to three of these bite elements were inserted into removable prosthetic appliances and were connected to associated electronic equipment.[4] Vertical forces on the teeth were recorded as deflections on a strip chart recorder. The tests were accomplished without interference or discomfort to the patients under observation. At maximum compression, the vertical movement of the strain gauge was limited to less than 0.5 mm.

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During the study two full upper and lower dentures, one partial lower against a full upper denture, and a partial lower against natural upper teeth were evaluated. Both partial dentures had one distal free-end extension and one tooth-supported segment. Nonanatomic acrylic posterior teeth were utilized wherever possible, except in the partial lower-natural upper teeth situation. In this instance anatomic acrylic teeth were used. Previous to each test, the occlusion was carefully equilibrated, and the experimental appliances adjusted so that approximately equal forces were exerted on all the teeth being tested at light, moderate, and maximum biting force. Fig. 1 shows the patient and all associated equipment under test conditions.

RESULTS

It was found that similar forces were utilized by the subjects during mastication of certain foods, regardless of the type of prosthetic appliance worn. Interindividual variations usually amounted to less than 12 per cent. The maximum force recorded during this study on a single tooth was 12 kilograms.

According to Table I, it may be observed that the average force required to masticate foods commonly found in the diet varied from 0.3 to 1.8 kilograms. Breads, meats, and raw fruits and vegetables seemed to require the highest forces in mastication. Table II presents a summary of the total forces required

TABLE I. AVERAGE FORCE PER TOOTH DURING MASTICATION

FOOD	FORCE IN KG.	FOOD	FORCE IN KG.
French roll	1.8	Ham on white bread	1.0
Tender steak	1.4	Lobster	0.8
Pear (hard)	1.4	Apple (Mac.)	0.7
Celery (raw)	1.3	Cucumber (raw)	0.7
Carrot (raw)	1.3	Raised doughnut	0.7
Bologna on roll	1.2	Broccoli	0.6
White bread ($\bar{c}$ crusts)	1.1	Potato (boiled)	0.6
Tomato	1.1	Crabmeat	0.5
Hard rye bread	1.0	Tuna fish	0.5
Hamburger (broiled)	1.0	Shrimp	0.5
Cole slaw	1.0	Cake	0.5
Lettuce	1.0	Boiled cabbage	0.4
Orange section	1.0	Boiled carrot	0.4
French roll ($\bar{c}$ liquid)	1.0	Boiled beets	0.3

TABLE II. FORCE IN KILOGRAMS PER TOOTH PER PORTION USED TO REACH SWALLOWING THRESHOLD

A.	B.	C.	D.
62 Carrots (raw)	19 Lettuce	9 Apple	3 Boiled carrot
42 Celery	16 Lobster meat	9 Raised doughnut	2 Boiled cabbage
31 Pear (hard)	16 Cheese on rye	9 Tuna fish	2 Boiled beets
31 Roll and bologna	14 Cold slaw	7 Shrimp	2 Cake
27 Dark bread	13 Raw cucumber	6 White bread, butter, and milk	
20 Broiled hamburger	11 Tomato	6 Crabmeat	
20 Tender steak	10 Ham on white	6 Broccoli	
20 Hard roll and coffee			

to render various foods ready for swallowing. It can be seen that there is a large variation in the total forces required to reach the "swallowing threshold."[6]

The question of whether the toughness of foods is related to the maximum forces utilized during mastication was approached by comparing the total forces utilized during mastication with the average force per stroke. A comparison of Tables I and II indicates that breads and raw vegetables required considerably higher mean and total forces than other foods to prepare them for swallowing. It was noted that the average forces used during mastication varied only slightly as compared to the total forces required to reach the "swallowing threshold." This may indicate that relatively constant forces are used with each masticatory stroke, and that difficulty in crushing is overcome by the application of more strokes rather than increasing the force per stroke.

It was noted that raw foods required two to three times the force that the same items required after cooking. The total work (as expressed by force times the number of strokes) required to render the food ready for swallowing was reduced by 83 to 96 per cent on the average. Certain rolls and breads with crusts required forces up to 12 kg. per tooth during mastication. The ingestion of liquids such as coffee, milk, etc., reduced the maximum forces, the mean forces, and the total kilogram strokes required at the swallowing threshold by about one-half.

The ingestion of large boluses of food did not materially affect the mean force recordings. In isolated instances, single forces increased due to placement of unsuitably large portions between the teeth. The patient quickly altered this situation by chewing only part of the bolus at a time. For the most part, forces characteristic of the food in 5 Gm. portions were observed. It was noted that the occlusal surfaces of the teeth rarely come in contact with each other during mastication. This was demonstrated by Jankelson[7] in the natural dentition, and by Brudevold[5] in denture wearers.

Fig. 1.

The denture wearers in this study exerted an average of 80 strokes per minute on most foods. The tougher foods were chewed at a rate of 65 strokes per minute. The partial denture wearers were slightly more rapid in their chewing cycle than full denture wearers, and averaged 100 strokes on soft foods, and 90 strokes on tougher foods.

FORCE DISTRIBUTION ANALYSES

Table III presents the findings with two full upper and lower denture wearers. The data are expressed in per cent of the total forces that were applied on each tooth, namely, the first bicuspid (4) and second bicuspid (5) and first molar (6). Mastication of hard rolls resulted in an almost equal force distribution among the three teeth studied. This was due to the fact that initially the rolls were masticated in the first and second bicuspid area, and, as they were softened, the molar area was utilized to a greater degree. The ingestion of liquids with rolls resulted in a slight posterior distribution of force. The raw vegetables studied were divided into soft and hard categories. Softer raw vegetables showed relatively equal force distribution on all three teeth, while tougher ones such as carrots were masticated in the first bicuspid area. The cooked vegetables showed a definite trend toward the posterior area.

TABLE III. FORCE DISTRIBUTION IN PER CENT KILOGRAM

TEST FOOD	TOOTH NUMBER		
	4 (FIRST BICUSPID)	5 (SECOND BICUSPID)	6 (FIRST MOLAR)
Hard rolls	30	40	30
Rolls plus liquids	24	45	32
Raw vegetables (tough)	41	33	26
Raw vegetables (soft)	37	31	32
Cooked vegetables	15	39	46
Breads	32	26	43
Bread plus liquid	20	27	58
Tough meat	19	48	33
Tender meat	19	29	52
Fish	28	39	33

When liquids were ingested simultaneously with bread there was a definite shift towards the first molar area in preference for mastication. Softer meats such as hamburger were definitely masticated in the molar area, whereas steaks were generally chewed in the bicuspid region.

We can conclude that with the same foods in different states of presentation preference for mastication occurs in anterior region when harder foods are chewed and the posterior region when the softer food are masticated. More specifically, the first bicuspid was utilized to a large degree with tougher foods, and the first molar with softer foods. The second bicuspid was utilized to a relatively constant degree with both hard and soft foods.

SUMMARY

A study has been conducted to evaluate the vertical forces that are placed on the teeth of full and partial dentures during mastication.

Relatively small forces were required for the mastication of most foods commonly found in the diet. Maximum forces up to 12 kg. have been recorded while chewing rolls and certain breads in the prosthetic situations. Six to eight kilograms were the most common maximum forces required. Most foods required an average force ranging from 0.3 to 1.8 kg. for mastication. Even though the average maximum biting force that denture wearers can exert is approximately 12 kg., they still possess an adequate force capacity to masticate the great variety of foods appearing in the diet. Full denture and partial denture wearers utilized similar forces during mastication.

Ingestion of liquids with certain foods by two denture wearers reduced the maximum forces and the total kilogram strokes used during mastication by about one-half. Cooking foods reduced the maximum forces by 50 to 75 per cent and also reduced the total forces needed to reach the swallowing point by 83 to 96 per cent.

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AN EVALUATION OF CONVENTIONAL CIRCUMFERENTIAL CLASPS

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THE CIRCUMFERENTIAL clasp consisting of a buccal or labial arm and a lingual arm which together engage more than 180 degrees of the circumference of a tooth, can be used correctly as a retainer for a partial denture only after its effect on the abutment tooth and its periodontium has been analyzed and made physiologically correct. If this type of clasp is used indiscriminately, it may exert harmful forces on the abutment tooth because of the failure to develop reciprocal action of the clasp arms. This is of special importance because the circumferential clasp is used so frequently and so often incorrectly.

A. *B.*

Fig. 1.—Models of posterior and anterior teeth viewed from the proximal surface showing heights of contour of the lingual and buccal (labial) surfaces.

Reciprocal action is that property engendered in a clasp by correct design whereby the transverse force exerted upon the abutment tooth by the retentive arm is neutralized by the stabilizing or opposing arm. When this objective is attained, it is the retentive arm and not the tooth that undergoes displacement buccolingually as the applicance is seated or removed. To achieve this objective

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the conventional circumferential clasp must fulfill three requirements. First, it must consist of a buccal or labial arm and a lingual arm that are of the same length, diameter, taper, physical properties, etc., in order that each would produce a force of equal magnitude. This is because deflection under bending force is directly proportional to the third power of length and inversely proportional to the fourth power of diameter, and deflection under torsional force is directly proportional

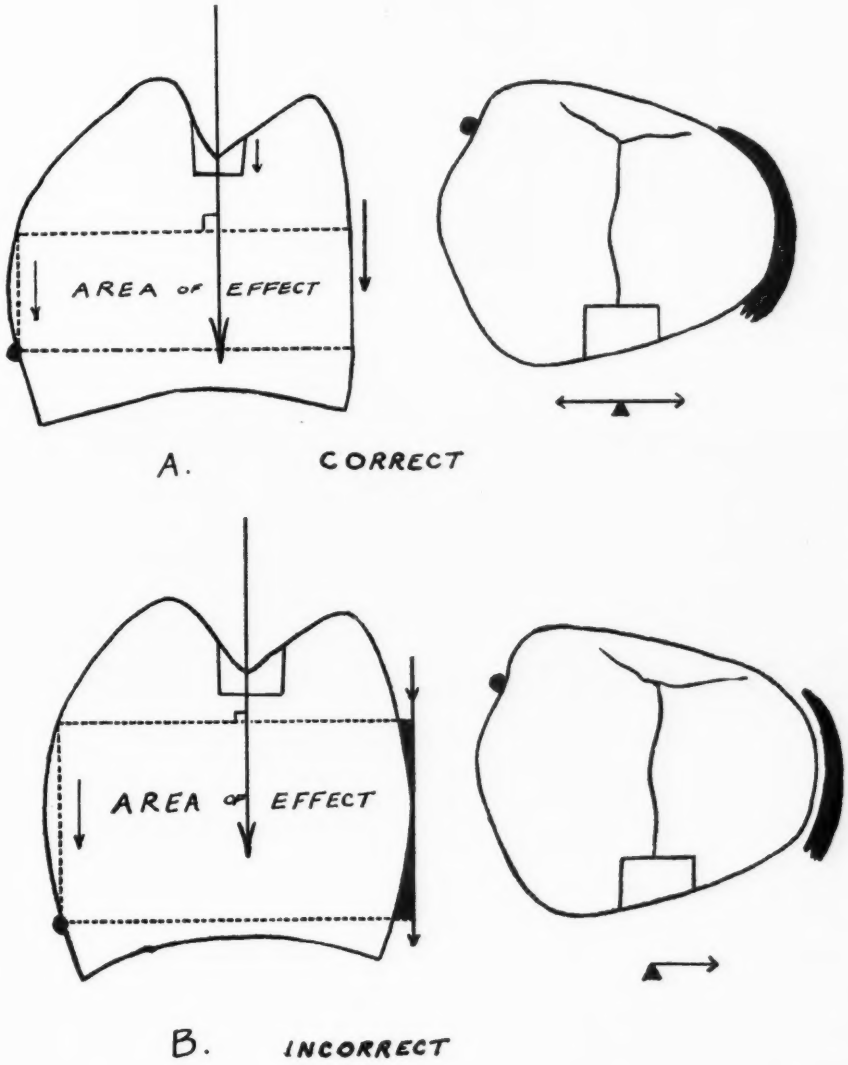
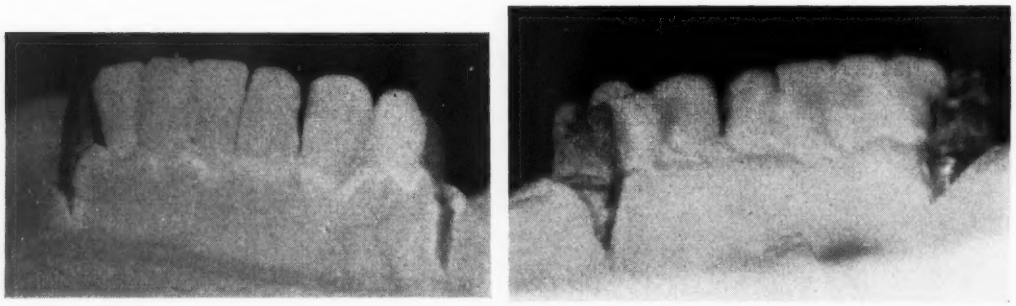


Fig. 2.—Diagrams illustrating the correct and incorrect lingual contours for obtaining reciprocal action by means of the lingual clasp arm. In *A* the lingual surface is parallel to the path of insertion and thus the lingual clasp arm contacts the lingual surface of the abutment tooth with reciprocating effect along the entire area of contact. In *B* the lingual surface has a natural contour. The lingual clasp arm will not contact the lingual surface of the abutment tooth except at the height of contour, the only point of reciprocating action.

to the length and inversely proportional to the fourth power of the diameter. Second, these identical arms must move in an equidistant but opposite direction simultaneously in one plane in order to neutralize each other's effect on the tooth. Third, if the nonretentive arm (usually the lingual) is made passive and inflexible as it should be, it would have to contact the lingual surface of the abutment tooth coincidentally throughout the entire time of action of the buccal arm.

Fig. 3.—A die of an abutment tooth with a quick-curing acrylic transfer cap fabricated upon it.



A. *B.*

Fig. 4.—A plaster cast with correctly seated abutment dies. This cast is placed on the surveyor at the tilt which provides the desired path of insertion of the partial denture. *A,* Labial view. *B,* Lingual view.

A review of the anatomic features of the buccal or labial and lingual surfaces of teeth reveals that their heights of contour normally differ. They are higher on the lingual surface on posterior teeth (Fig. 1) and variable on anterior teeth. The entire lingual surface of posterior teeth and the gingival third of anterior teeth cannot offer a surface conducive to reciprocal action by a passive lingual arm except at the height of contour because of its convex form (Fig. 2, *B*). This position is reached only when the partial denture is seated and the retentive arm is in a passive state. Hence, the desired balance cannot be achieved with the conventional circumferential clasp on teeth of anatomic form as they exist. Therefore, provisions must be made for attaining this reciprocal action by modifying the contour of the lingual surface of the abutment tooth or by modifying the design

of the circumferential clasp. The former is accomplished by means of full cast or acrylic-faced full cast crowns (Fig. 2, *A*). These also enable the operator to use longer retentive clasp arms with greater flexibility by altering the contour of the retentive surface more favorably.

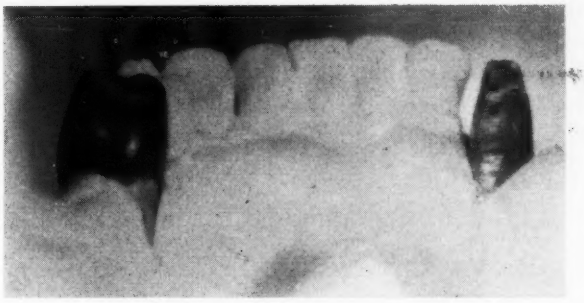


Fig. 5.—A plaster cast with correctly seated abutment dies, one of which carries the surveyed and corrected wax pattern for a crown.

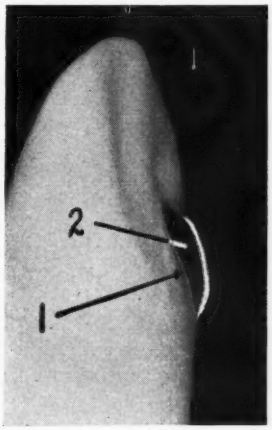


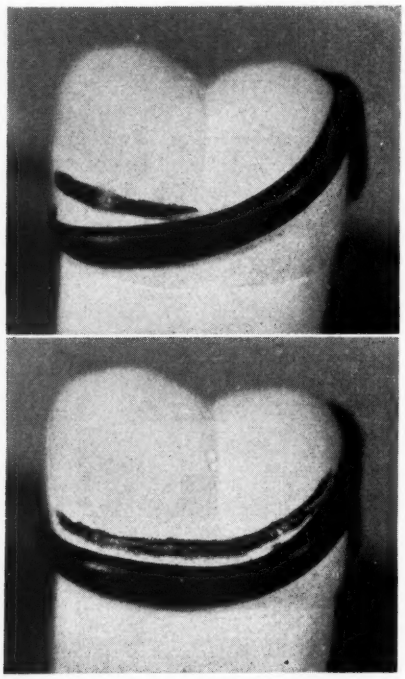
Fig. 6.—A model of mandibular cuspid showing the contour of the lingual surface. *1*, The natural contour of the cingulum which is unsatisfactory as a reciprocating or stabilizing surface. *2*, The built-up cingulum as suggested for crowns. This affords a more desirable surface for reciprocal action and stabilization.

CAST CROWN TECHNIQUE

The method of fabrication of the crowns is as follows: The abutment teeth are prepared and impressions for dies are made. The dies are made and trimmed, and low-fusing metal or quick-curing acrylic caps are fabricated on them (Fig. 3). These caps are seated on their respective teeth, and a plaster impression (or an elastic impression in suitable cases) is made of the entire arch of teeth. The dies are seated in the transferred caps, and a plaster cast is poured (Fig. 4). The cast is placed on the surveyor at the tilt providing the desired path of insertion of the partial denture. The wax patterns of the crowns on the dies are surveyed

and corrected by trimming or adding wax (Fig. 5). The lingual surface is so designed as to have its major portion parallel to the path of insertion (the cingulum of the anterior teeth is built further toward the incisal edge than it is in natural teeth) (Fig. 6), while the buccal surface is modified by lowering the height of contour to provide a means of fabricating a more flexible, longer and more esthetic buccal arm (Fig. 7). The crowns are cast and polished and then checked on the surveyor. This insures a surface of continuous contact for the stabilizing lingual arm within the area of function of the retentive buccal arm.

A.



B.

Fig. 7.—*A*, A model of a mandibular molar with a natural height of contour which illustrates the position of a cast buccal retentive component of a circumferential clasp. *B*, A model of a mandibular molar with full-cast crown which illustrates how the cast buccal retentive component of a circumferential clasp can be lengthened by moving the height of contour gingivad. The position of the natural height of contour is indicated for comparison.

CLASP MODIFICATION

Where the lingual surface of the abutment tooth cannot be modified by means of a restoration, that is, where the natural contour of the tooth must be maintained, the clasp is modified. The reciprocal action of the clasp on that kind of tooth is obtained by means of a cast, rigid, upright bar. This bar is a part of the harness on the tooth. The contacting surface of the bar is parallel to the path of insertion

and is, therefore, in continuous contact with the height of contour of the abutment tooth during the insertion or removal of the appliance. It is evident that this bar must not engage any undercuts (Fig. 8). It is, as a rule, placed in the quadrant away from the minor connector to the clasp (Fig. 9). In this manner, provision is made for the protection of the abutment tooth from orthodontic movement with its associated breakdown of the periodontium. It makes it necessary for the retentive arm to flex and ride over the prominence of the buccal or labial surface of the tooth. If this cannot be accomplished, the denture will meet resistance in its seating, an indication that adjustment is required. Thus, one possible cause of failure of the partial denture, namely, the loosening of the abutment tooth by the clasp, is eliminated.

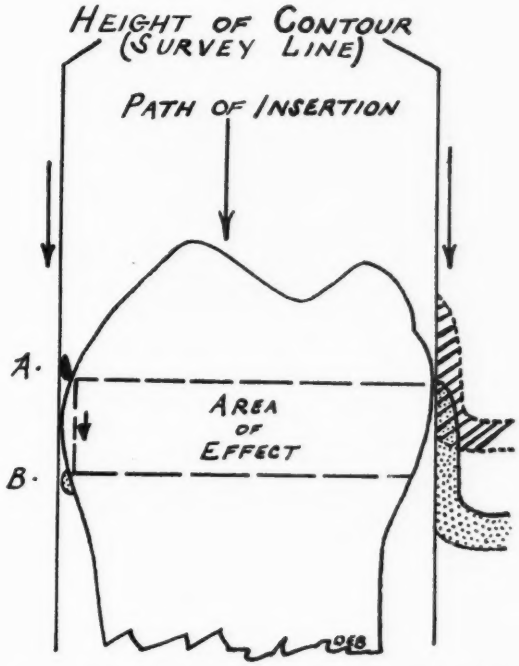


Fig. 8.—Diagram of the position and functioning of the cast upright reciprocating bar for a natural abutment tooth. *B* is the position of the harness seated with the retentive buccal clasp arm passive in its undercut. *A* is the position of the harness during insertion (or removal) where the buccal arm begins its effect on the abutment tooth. The rigid upright bar contacts the lingual surface of the abutment tooth during the entire interval that the retentive arm is tending to push the tooth lingually.

In order to attain reciprocal action of clasps, it is necessary that the minor connectors (tangs or struts) involved be rigid. Otherwise the effect of the reciprocating bar on mesiodistal thrusts would be negated. This reciprocation involves the combined effect of the rigid lingual arm and minor connector. It prevents the retentive portion of the buccal arm from pushing the abutment tooth in a mesial or distal direction. The direction of the thrust depends upon the relationship of the retentive arm to the buccal surface with its retentive undercut (Fig. 10).

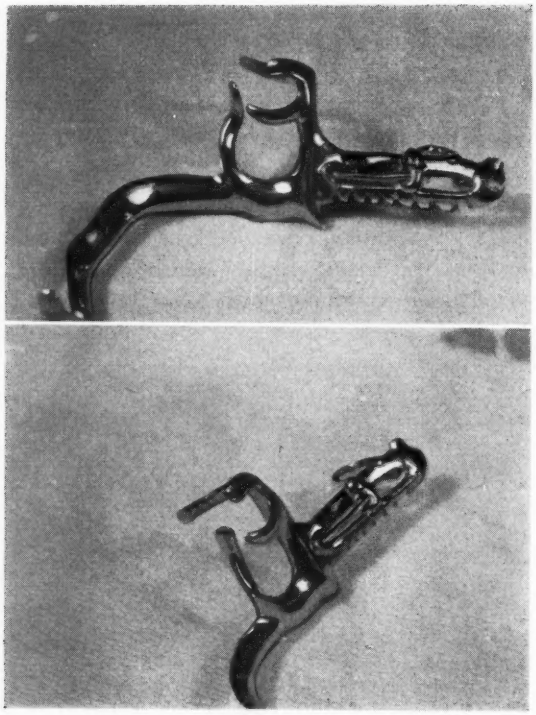


Fig. 9.—A cast mandibular distal extension saddle harness for a patient with unprepared abutments. Note the upright lingual bar to provide reciprocal action.

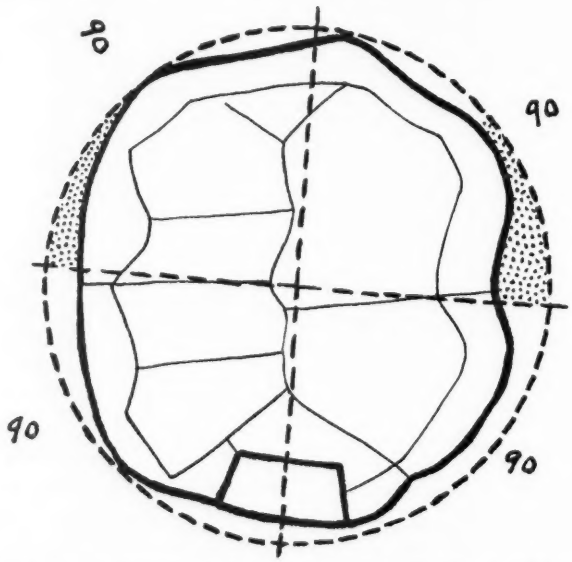


Fig. 10.—Diagram of the reciprocation principle of clasp action, and the need for a rigid minor connector. The abutment tooth is visualized as a circle (360 degrees), with four quadrants of 90 degrees each. The clasp should encompass or affect more than 180 degrees of the tooth, and thus the ends of the respective clasp arms should reach the shaded areas. The tendency of the flexible end of the retentive clasp to push the abutment tooth away from itself is reciprocated by the rigid minor connector in the region of the occlusal rest.

The need for reciprocating action in clasps has been established.[1, 2, 3] A proprietary booklet of wide distribution mentions, in part, that in chewing in some patients, "the buccal arm will constantly nudge the abutment tooth toward the lingual. As soon as such movement starts, however, the lingual arm becomes engaged and reciprocates, thus preventing movement of the abutment tooth." It also states that "if clasp arms reciprocate on opposite sides of the tooth, resulting tendencies to abutment tooth movement will more nearly cancel each other and so preserve abutment tooth stability." These statements are inadequate because they are limited to action that occurs only when the appliance is seated and the lingual arm is on the height of contour. The fact that there should be lingual contact at all times is not mentioned. No description is given of the effect of insertion and removal of the clasp upon the abutment tooth.

Therefore, it depends upon the operator to visualize the entire effect of the clasp upon the tooth and its periodontium and to plan and execute his denture accordingly.

CONCLUSIONS

1. The circumferential clasp is frequently used incorrectly for retaining partial dentures.
2. Reciprocal action in a clasp is essential to its proper use.
3. Reciprocal action must be maintained during insertion and removal of the appliance as well as after it is seated.
4. Continuous reciprocal action may be obtained by modification of the abutment tooth by crowns or by modification of the clasp itself.

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THE PRACTICAL APPLICATION OF SOUND PRINCIPLES TO THE FIELD OF RESTORATIVE DENTISTRY

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THERE are two common ways of doing things. One is by rules, without one's knowing the reasons and hoping that the rules are sound. The other is also by rules, but rules which are backed up by reason, principle, and understanding. By understanding fundamental principles, anyone can develop and modify rules for varied situations. The field of restorative dentistry presents, daily, varied and complex problems which can be intelligently solved only by the application of sound principles.

A young dentist takes his degree and starts to practice with a minimum of knowledge, by our standards, to serve the public. He has learned some principles and many rules of practice. If he is alert, his fund of knowledge grows each year. He gradually learns the principles back of the empirical rules by which he started practice, and therefore grows in judgment. There are hundreds of principles governing sound restorative procedure, of which time permits discussing several important and random examples.

Dr. G. V. Black[1] is the outstanding figure of the century in the restorative field. He pioneered in classification and application of sound restorative principles. Although Black has been dead for thirty-six years, his contribution to society is immortal. If his teachings were even today completely understood and followed, contemporary restorative dentistry would be tremendously advanced. Admittedly, there has been progress in the years since Black wrote his last paper, but *sound* progress is based upon the *complete* utilization of the heritage of the past. Some of Black's profound truths are being ignored by many members of our profession.

In his long lifetime, Black searched out and assimilated all that was good in past and current restorative procedure. Much dental information in those days was considered close personal and proprietary secret. To build upon those findings, he conducted exhaustive research, inventing and building his own scientific equipment. Giving full credit and recognition to the contribution of others, his results were unselfishly shared with the profession and carefully recorded for our guidance. Many of his teachings seemed startlingly new and bold then, but

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time has proved them almost universally sound. Black brought restorative dentistry completely up to date in his lifetime. His teachings are therefore a dependable record of the first two-thirds of our "Century of progress in dentistry." A review of this subject can be properly divided into two parts, first, Black's teachings, and second, "post-Black" accomplishment.

REVIEW OF FIVE OF BLACK'S PRINCIPLES IN RESTORATIVE DENTISTRY

Principle 1.—Operating in a clean field.

Black taught that cavity preparation should be finished and restorations should be placed in completely dry, clean fields of operation.[1] He taught that any cavity contaminated with mouth fluids or drugs would produce a leaking restoration, and that contaminated cavity margins should be recut before filling.

Cemented fillings are in some measure an exception and a compromise to this rule. An inlay inevitably must be placed into a cavity contaminated between the first and second appointments. The cement fortunately will bind a small residual amount of debris. Many inlays fail, however, partly because a gross residue of oily temporary filling, wax, mucin plaque, and other foreign material is not thoroughly scrubbed off and dried before cementation. Routine scrubbing of cavities with chloroform will remove the oily residue. Hydrogen peroxide will aid in removal of organic material.

Black taught that careful cavity preparation can be done only in a clearly visible field. He taught that dental caries is best stopped by complete caries removal, which requires clear visual inspection. The best cavities, and patterns or impressions, are made under a dam. Black recognized the great affinity of phosphoric acid of crown and bridge cement for water. Water-contaminated cement is weak and soft.[1] Therefore, he insisted that inlay restorations be cemented, as well as the preparation finished, in a dry, clean field.

Can we serve our patients honestly today if we ignore the application of these principles? Black recommended routine use of the rubber dam[1] as the simplest dependable means for providing a clean, dry, visible field of operation. Those operators who do use the dam routinely learn to apply it quickly and simply. They find very few situations where it cannot be used. Their patients regard the use of a dam as an essential part of good dental service. Yet we see graduates, even from dental schools which recognize and teach the merits of the dam, almost completely abandoning its universal need. Why?

Principle 2.—The four most desired qualities of restorative materials in the order of importance according to Black are:[1]

1. Indestructibility in the fluids of the mouth.
2. Adaptability to the walls of the cavity.
3. Freedom from shrinkage or expansion after having been made into fillings.
4. Resistance to attrition and sustaining power against the force of mastication.

The three qualities of secondary importance are:

1. Color and appearance.
2. Nonconductivity to thermal change.
3. Convenience of manipulation.

The only possible change we might make today would be to move the first of the secondary qualities up to fifth place in the primary list. That is, to include "appearance" in the primary list, but still not place it ahead of the other four.

In application, do we always recommend for our patients the restorative material that will serve them best, all factors being considered? What about the dentists who seldom or never use gold foil, the best of all restorative materials? Useful though gold inlays are, we must not forget that the metal-to-tooth seal of amalgam and gold foil alike is superior to the cement seal of even the best gold inlay.

Do we properly weigh the properties of a new and highly advertised material by these proved standards? How many disappointments could have been prevented, in the years since Black, in the use of silicate cements and acrylic resins by applying his "sound principles" to judge their merits, and then using these materials reservedly, in areas which involve neither stress nor contact.

Principle 3.—Black developed the box type of cavity preparation[1] with its retentive outline, its maximum resistance to forces of stress, and its conservative "extension for prevention"[1] of recurrent caries.

Yet in more recent years a portion of our profession has been misled to adopt the mutilative "slice" preparation, woefully deficient in retention, with thin margins that curl and fail. Slice preparations do not provide adequate extension for prevention despite a disfiguring display of filling material. Sound scientific principle has been sacrificed to a false concept placing "speed at any cost" ahead of "service."

How will cavity preparation by means of a sandblast suit these rigid standards of precision and conservation? Airbrasive *may* become a most useful operative instrument in the hands of a careful operator. It will definitely magnify the errors of careless operators, and in those hands become a positive menace to dental practice. Perhaps the same was said of the first dental foot engine, which Black helped to perfect.

Principle 4.—All cavities should be prepared so that restorations are seated upon sound dentin.[1]

Skinner has shown various dental cements to have from one-fifteenth to one-fourth the crushing strength of silver amalgam.[2] This supports Black's contention that cement should be used but sparingly as foundation and insulating material under restoration.[3] An island of metallic filling seated upon a sea of cement can give but temporary service, at best. Silver amalgam, however, makes splendid foundation material for cast gold restorations. It can be strategically used in deep gingival situations inaccessible to gold.

Principle 5.—Keeping abreast of the times.

Black has said that ". . . no professional person has a right to be other than a continuous student." Every restorative dentist can benefit by periodically re-reading Black's writings. Recognizing the contribution of the first two-thirds of a century as aided and recorded by Black, what additional progress has the last third of a century brought?

CONTROL OF PAIN

Although pain control by drugs originated more than a century ago with Dr. Horace Well's memorable use of nitrous oxide, *routine* easing and control of pain for dental *restorative* procedures is a development of the last one-third of a century. Ostrander, long a member of the American Dental Association Council of Dental Therapeutics, has said, "A dentist is not only privileged, but *obligated* to give his patients the benefits of drugs for relieving pain, nervous tension, and anxiety from dental operative and restorative procedures." The American Dental Association handbook of accepted dental remedies lists such drugs, together with their properties and uses,[4] for the benefit of our patients.

CONSERVING THE NATURAL TEETH

All substitutes for natural teeth are distinct compromises. Dental science restores defective teeth to healthy, serviceable function, replacing them only where absolutely necessary. Developments of the past one-third of a century make the loss of natural teeth seldom necessary.

Zander,[18] Easlick,[5] and others have outlined successful methods for pulpotomy (partial pulpectomy); endodontic service has been developed to a fairly exact science, healthfully preserving useful teeth for subsequent restoration. Biologic progress is safeguarding the investing tissues of the teeth. Periodontal care has become more and more of an exact science, better insuring the value of restorative service.

PULP CONSERVATION

Restored teeth should be very comfortable after filling. If recently restored teeth react sharply to hot or cold foods, it is almost certain that they have been subjected to unnecessary shock during the restorative procedure.

Vital pulp structure heated to temperatures exceeding 136° F. will be injured. Dentinal fibrils are extensions of the dental pulp and must be considered as pulp tissue. In application, cavities should be cut in either a very wet or very dry field, either under a continuous stream of running water or of air, to prevent the heating of vital tooth structure past the low critical temperature of 135° F. Increased speed of modern dental engines to 5,000 r.p.m., although enhancing the efficiency of rotary cutters, creates the increased hazard of thermal shock. Research is being conducted in further vastly increased bur speeds, to 12,000 or perhaps even to 20,000 revolutions per minute. The principle of thermal control in cavity preparation becomes increasingly important. As we prepare cavities, we

can always visualize the principle which primitive peoples learned long ago that fire could be started by rotating one stick against another.

The routine use of caustic or heroic drugs is unnecessary in the restorative procedure.

True, pulp fibrils injured by overheating can be quieted by cauterization. The fallacious routine cauterization of cut dentine with phenol simply attempts to correct one evil with another. Following careful cavity preparation, no drug at all need be placed into a cavity. The only exception is the very occasional case where removal of the last vestige of questionable dentine might bring a pulp exposure. Here we may risk the use of silver nitrate where staining can be tolerated, or of beachwood creosote, for an anterior tooth in order to "sanitize" the cavity.[6] Then the "mess" thus created must be carefully cleansed from the cavity, scrubbing it out repeatedly with chloroform, then recutting the enamel margins.[1] Copalite varnish has been developed for effective routine cavity insulation and protection, eliminating the need for any other cavity treatment.

CAVITY MODIFICATION FOR ESTHETICS

Returning again to the subject of cavity preparation, there has been wholesome progress here. Black dealt with a public unenlightened in present-day knowledge of dental hygiene and preventive measures. If he were still living he might have been among the first to modify his cavity outlines toward conservation of tooth structure for those individuals most conscious of esthetic harmony, and willing and eager to protect conservatively placed margins.

In the years since Black, we respect the conservative teaching of True[7] in his modification of the Class III gold foil outline of Woodbury.[8] Woodbury's cavity in turn improved both the esthetics and strength of Black's classical Class III preparation. Tinker's[10] three-quarter veneer crown and subsequent modifications of pinlays and pin-inlays have largely displaced the shell crown for anterior restorations and abutments.

The modern trend is to further modify cavities to favor various restorative materials.

Bronner[9] advocated applying Black's principle of the Class IV cavity outline to Class II cavities for amalgam, thus placing more stress upon tooth structure and less on the hard, but brittle, amalgam. Even greater conservation[3] than suggested by Bronner finds application in present-day restorations of silver amalgam.

Ingraham and Potter, working together at the University of Southern California, have done much to teach conservation in restorative procedures,[10] yet speeding cavity preparation with modern diamond abrasives.

Woodbury has recognized the merits as well as the weakness of silicate cement, which may be applied to the new plastics as well. He advocates the cutting of ulra-conservative cavities for them, separating the teeth for proximal cavities so as never to include the contact where possible to avoid it, and recognizing that even weak enamel is better than these weaker filling materials. Over a period of years such a filling can be periodically replaced, each time into a slightly larger cavity,

which only after a number of replacements approaches the size of Black's classical three and five outlines.

PRINCIPLES OF PRECISION-FITTING CAST RESTORATIONS

The last one-third of a century has brought marked progress in the perfection of precision gold inlay castings. A poorly fitted cast restoration is only a little more permanent than an admittedly temporary filling made from the cement with which an inlay is set. All precision casting techniques depend upon exacting chains of technical procedures.

PRINCIPLES OF CAST-RESTORATIVE TECHNIQUE

There are several variables and shortcomings in cast restorative work that still cannot be completely controlled, even by the most careful operators. All cast restorations are therefore compromises to a varying degree. A host of principles could be listed for cast-restorative technique alone. Perhaps the three most important groups are:

1. *Cavity Preparation for Cast Restorations.*—For cast restorations, a cavity must have, in addition to the qualities necessary for all other durable restorations, draft. Draft allows the rigid casting to be inserted into or over the preparation without interference of undercuts. Too much draft robs the restoration of retention. To allow a free sliding fit, all preparations must have smooth walls and polished margins. Where such coarse abrasives as diamond stones are used, they must be followed by other finer instruments for finishing the cavity.

A cavity of any size weakens a tooth, making it more susceptible to fracture. One of the advantages of cast restorations is the strengthening of weak tooth structure possible with them. This principle should be utilized to the utmost in cast-restorative work by protecting occlusal surfaces against splitting, by capping frail cusps, and with buccal and lingual extensions tying weakened tooth structures together so that it cannot split in function.

2. *Patterns.*—All cast restorations are made from wax patterns which are fabricated either directly upon the prepared tooth or upon as accurate a die or cast as can be made of it. Much recent progress has been made to reduce the variables of cast reproduction, through the development of better impression and die materials and techniques. Whether the pattern is made upon a die or in the mouth, wax pattern variables exist. They can be reduced materially by understanding the principles involved.

Van Horn, Lasater,[20] Phillips,[11] and others have applied the principles of wax variables to precision casting briefly as follows: The tendency of wax to acquire strains during manipulation causes it gradually to change shape. Strain formation can be reduced by routinely storing pattern wax sticks, preparatory to their use, in an annealing oven at 120°F. To compensate for the tendency of wax to warp, patterns should be invested immediately and at room temperature. If they must be stored briefly, they should be kept in the freezing compartment of a refrigerator. Indirect patterns are best made by flowing melted wax onto a stone die.

3. *The Principles of Investing Procedure.*—Present-day casting investments compensate for wax pattern shrinkage from mouth or fabrication temperature to room temperature (0.02 per cent per degree Fahrenheit) plus the shrinkage of gold from the molten stage to the solidified stage, an approximate 1.25 per cent. This compensation is accomplished by setting expansion, which is generally a combination of hygroscopic and true setting expansions, plus enough thermal expansion to make up the balance of the approximate 1.65 per cent total needed. Wax pattern resistance interferes with accurate setting expansion. Therefore, the ideal investment would have neither hygroscopic nor setting expansion, but would depend entirely upon thermal expansion, controlled by the exact degree of heat applied. Such an investment probably can and will be produced within the next year or two. Even at present, casting procedure is a fairly exact science.

In recent years, vacuum investing[12] has made possible the complete elimination of mold discrepancies caused by retained air bubbles. The technique is based upon the principle of Boyle's law which states that gas volume varies inversely as the pressure upon it. Numerous equipments are now available for vacuum investing. A pattern must be well cleaned and dry at the time it is invested, otherwise a rough casting results.

PRINCIPLES GOVERNING AMALGAM RESTORATIONS

1. As has been previously mentioned, a cavity preparation should be used which *complements* amalgam's good properties and *minimizes* its weak points. Strength is derived from bulk and square margins. Strong tooth structure should be conserved to carry the load, otherwise cusps should be generously capped with at least 2 mm. of amalgam.

2. Four rigid confining walls are necessary to support the necessarily heavy condensation pressure of amalgam without the hazard of "landslide" movement within the mass. Missing walls must be supplied by a completely rigid matrix, preferably one which faithfully restores tooth form in those areas which cannot be readily carved and polished.

3. An American Dental Association approved alloy[2] gives the operator the assurance that a good amalgam can be made, other factors being favorable.

4. Accurate proportioning[2] assures enough mercury for complete amalgamation without excess.

5. Complete amalgamation allows for condensation without voids. Overtrituration creates a shrinking filling.[2] At no stage should additional mercury be added.[18]

6. Correctly amalgamated and condensed alloy expands slightly while setting, from 3 to 12 microns per centimeter. This insures a tight filling in the cavity,[2] one which will not leak despite temperature changes.

7. Thorough condensation adapts the amalgam intimately to cavity walls, eliminates voids, and brings excess mercury to the surface where it can be discarded. Mercury content of the mass should be reduced to 50 per cent or less for strength. Amalgam condensers must be shaped to fit and must be made to

condense material into every part of the cavity. Sufficient condensing force can be created only with medium and small condensing surfaces for thorough amalgam condensation. Large condensers reduce the effective condensing pressure inversely as the square of the diameter of the condenser face.[2] Skinner computes the comparative effective condensing force resulting from a ten-pound thrust with 1 mm. and with 3.5 mm. diameter condenser points. The 1 mm. instrument will create 8,250 pounds per square inch, compared to only 670 pounds effective force with the 3.5 mm. diameter condenser face.

8. Moisture contamination causes voids and delayed expansion. Absolutely no moisture contamination can be tolerated during handling and condensation of amalgam.[14]

9. Amalgam should be polished and the final trimming done at a second appointment, preferably three or more days later. Unpolished amalgam will corrode even if all other factors are perfect.[15, 16]

FIXED BRIDGE PRINCIPLES

1. An unusual inlay is required as a fixed bridge attachment. Retention must be engineered to support every possible stress. Experience dictates using the strongest possible attachment that esthetics permit. Since complete encirclement of an abutment tooth gives the strongest possible attachment, complete crowns should be routinely used for second and third molar and some lower first molar and bicuspid abutments.

2. Favorable occlusal situations should be created in fixed bridge cases. Functional balance should be perfected and maintained. The longer the pontic, the narrower the occlusal surfaces should be to prevent overloading of abutments.

Where anterior teeth normally touched in centric occlusion, cingula must by all means be restored on upper anterior bridges. Otherwise lower anterior teeth will extrude eventually to cause destructive imbalance.

3. Broken stress will relieve many of the torsional strains created in service by one abutment resisting the functional movement of another.[17] A safety factor is thus created which will protect the weaker attachment from being wrenched loose from its abutment.

PRINCIPLES OF PREVENTIVE CARE

1. Biology has brought better understanding of caries cause and control. Caries-control measures were practically unknown in the time of Black. Such dietary measures as control of carbohydrates, particularly of refined sugars; cleansing of the teeth and investing tissues immediately after meals; fluoridation of drinking water; topical application of such preventives as fluorides, ammonium compound, and chlorophyl now have recognized merit.

2. Saliva tests for appraising the rate of caries susceptibility and control have been perfected and are available through many state dental health services. Service from restored mouths is enhanced with the growing list of preventive measures.

3. Routine care of patients is necessary to safeguard their dentition. Dental science restores defective teeth to healthy function, it is true. Yet the making of

repairs alone is not enough to preserve the natural dentition. Restorative dentistry, to be effective, must go hand in hand with periodic examination, with education and supervision of patients in preventive measures. These inseparable services, together with the quality of restorations, control restorative success.

Honesty and integrity, a *general* principle.

Here is one *final* principle which is fundamental in all kinds of endeavor, *including* restorative dentistry. It is our professional duty to protect the public by giving every patient our most sincere effort.

CONCLUSION

Restorative dentistry can be, without further technological advance, vastly improved by self-education within the profession. Working and thinking by principle rather than by rule leads to sound restorative procedure.

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A CONSIDERATION OF THE TEETH DURING AND FOLLOWING THEIR PREPARATION FOR GOLD JACKETS

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UNLESS careful consideration is given to the protection of the pulps of teeth undergoing preparation for full gold jacket coverage, irreparable damage may take place. This is also true of the interim period following preparation but before the finished jackets have been inserted. This article will describe a technique which is aimed at preventing injuries to the pulps both during and after preparation of the teeth for full coverage.

During the preparation, care must be exercised not to generate excessive heat by the use of engine-driven equipment. Frequently, enough frictional heat can be developed to sear the protoplasm of the fibrillae and literally cook the pulp in its own juice. As Seltzer[1] mentioned, "Some apparently unexplained pulp deaths are due to this factor, even though symptoms may not be manifest for quite some time after the original injury was incurred. The use of a water spray helps to reduce frictional heat considerably. In the use of discs and stones, laceration of the cervical gum tissues must be avoided if possible. Severe lacerations will cause recession of the gingival tissues, and are often the cause for shyness of the jackets at the gingival margins."

After the teeth are prepared, a generous coating of Copalite should be applied. This will seal the dentinal tubuli and help prevent thermal shock. Kerr's die lubricant should be painted on the teeth to facilitate the making of the individual impressions. Compound impressions are then made in copper bands. Two inlay wax occlusal records are made of each prepared tooth to register the proximal contact and occlusion. With one of these, a temporary cover for the preparation is constructed. This is the means for retaining the prepared tooth in its correct position. The other is used to construct a transfer coping for accurately seating the amalgam die into a plaster impression. Finally, the gold jackets are made on articulated casts. Amalgam, stone, or electroplated dies should then be made. Amalgam dies are used since they can be made more quickly than the others and have sufficient strength to withstand the fabrication of both the temporary and permanent jackets. The amalgam dies are dressed down and the root ends are tapered so that they can be used in the working casts. The gingival finishing line is inscribed on the dies with a saucer-shaped carborundum disc, followed by a No. 38 inverted cone burr.

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The previously mentioned wax occlusal records are fitted on their respective dies, and the waxing is completed to form full covers. Several of these can be mounted on one base and cast at the same time. The vacuum investing technique is used because it is so much easier to get the investment into the inner portion of the wax jackets without trapping air. After the investment has set, the rings are placed in the burnout oven and cast in the usual manner, using Goldsmith's C. I. metal for making these castings.

Aluminum shells of proper sizes are then festooned and fitted for occlusion, and placed on the teeth with zinc oxide eugenol paste. These will protect the teeth during the time it takes to make the base metal castings. It is advisable to place a sedative dressing on the teeth after they have been prepared for full coverage in the majority of cases. This procedure allows the pulp to recuperate from the trauma and irritation of their preparation. This is especially necessary in younger individuals. It is important that these aluminum shells do not impinge upon the gum tissues, and that they do not cut the periodontal attachments.

The practice of leaving prepared teeth uncovered until the cast jackets are constructed should be discontinued because (1) in freshly cut dentin, millions of tubuli are opened. Unprotected fibrils not only become extremely sensitive when exposed to oral fluids, but resultant irritation and infection may eventually lead to death of the pulp.[1] Many cases of continued sensitivity after insertion of the finished restorations are due to a previous history of exposure to saliva. (2) Occlusal clearance can be lost in a very short time. This would necessitate further reduction of the occlusal surfaces of the teeth, and the construction of new jackets in a great number of instances.

At the next visit the base metal castings are tried on the teeth. They are checked for occlusion, contact, and gingival fit. At this point, and before the final gold jackets are constructed, the accuracy of the finished crowns can be determined. If everything is satisfactory, the base metal castings are cemented on the prepared teeth with zinc oxide eugenol paste. There need be no rush after this to complete the jackets, as the teeth will be retained in their proper positions and be comfortable.

In conspicuous areas of the mouth, I cut out the labial or buccal surface of the wax when making the base-metal jackets After casting and fitting these to the teeth, I undercut this surface and place either synthetic porcelain or self-curing acrylic in his portion of the jacket. This makes a very inconspicuous temporary restoration.

In long preparations, it is advisable to lubricate the inside of the base metal jackets to facilitate their removal. Also, a horizontal notch is placed on the buccal surface of these castings so that a discoid or similarly shaped instrument can be placed in the notches to aid in the removal of the jackets. Clayman and his co-workers[2] place Buckley's desensitizing paste in the temporary covers so that the teeth are much less sensitive when it comes time to place the permanent jackets.

In the final cementation oxyphosphate of zinc cement is used with a drop of eugenol added to the liquid. This also seems to reduce the sensitivity of these teeth.

SUMMARY

1. Excessive heat should be avoided when using engine driven equipment by means of a water spray.

2. Lacerations of the cervical tissues must be avoided, if possible, because this will cause recession of the gingival tissues, and is often the cause of shyness of the jackets at the gingival margins.

3. The teeth should be covered immediately following their preparation for full gold jackets to allow the pulps to recuperate from the trauma and irritation of the preparation.

4. Properly fitted aluminum shells are cemented in place with zinc oxide eugenol paste until the base metal jackets are made.

5. Base metal jackets should be constructed as soon as possible to retain the teeth in their original position, and keep them comfortable.

6. In the final cementation of the jackets, a drop of eugenol is added to the oxyphosphate of zinc cement. This will reduce the sensitivity of the teeth considerably.

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STANDARDIZED CROWN AND BRIDGE PROCEDURE

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THE fixed bridge, when properly executed, is the best restoration for the replacement of missing teeth. It is also dangerous to attempt when the necessary technical skill and knowledge of fundamentals are lacking. Indeed, there are very few practitioners who have not experienced some failures with bridgework.

The causes for failures in bridgework are:

1. Caries around the margins of abutment restorations.
2. Loosening of the abutment teeth.
3. Irritation and inflammation of soft tissues.
4. Fracture of pontics.
5. Poor color and discoloration of acrylic veneer facings.
6. Lack of occlusal harmony.
7. Inefficient mastication.

REQUIREMENTS OF A GOOD TECHNIQUE

Technical skill for any type of work is developed and achieved only after varying periods of trial and error. Experience is the great leveler for any technical procedure. However, as we work out our procedures, certain requirements become apparent.

The technique we employ should be as simple as is practical. The steps taken should be neither time-consuming nor complicated. In any given situation, the simpler we keep our work the more likely we are to want to do it. Complicated methods do not necessarily mean better results.

We should also have a thorough knowledge of the scope and limitations of our technique. This implies the inclusion of our planned technical procedures in our diagnosis and treatment planning. We must look ahead to the actual execution of the work when we decide what we are going to do for the patient. This also implies flexibility and adaptability of the technique to most situations.

No consideration of a technique would be complete without giving attention to the problem of the fee. There are many fine methods of constructing a fixed bridge which employ costly articulators, the services of specially trained technicians, and other factors which place the cost of this type of dentistry beyond the reach of the average patient. It behooves us, therefore, to try to incorporate into our routine those practices which will achieve good results with a minimum of cost.

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DIAGNOSTIC CONSIDERATIONS

It is generally conceded that the construction of a fixed bridge is a difficult and complicated procedure, requiring more than just replacing missing teeth. In removing teeth in oral surgery, a knowledge of anatomy, density of bone, nerve supply, etc., are essential prerequisites. Similarly, bridge construction requires the application of much theory and training in basic sciences, and their particular application to a very narrow part of the whole dental science. Thus, diagnosis and treatment planning become all important initially. When to use a fixed bridge? What type of abutment should be used? Are single or multiple abutments indicated? These are a few of the questions which must be answered.

Fig. 1.

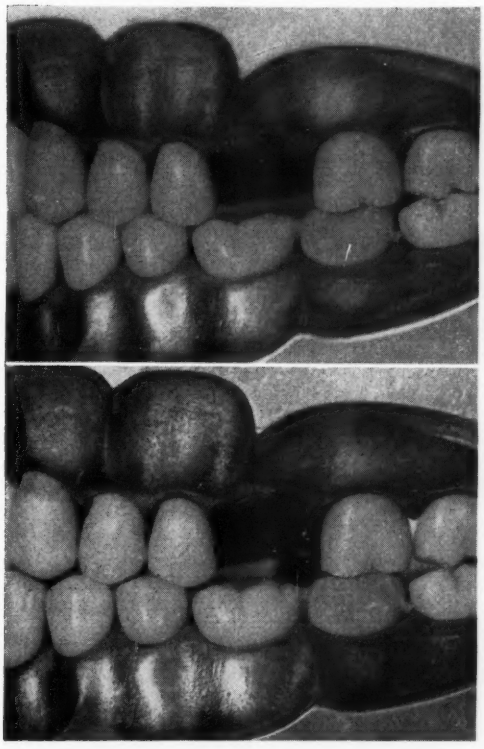

Fig. 2.

Fig. 1.—Before treatment.
Fig. 2.—Occlusion is adjusted before preparations are made.

In order to expedite the treatment, full mouth radiographs and mounted study casts are essential. A complete oral examination, with a careful notation of the vitality and mobility of the teeth, pocket depth, caries, etc., is made. Occlusal disharmonies, the color and tone of the gingival tissues, the general architecture of the mouth, and the medical history are recorded. From all the facts gathered, certain conclusions can be drawn as to the possibility of success. From these conclusions, the final diagnosis is made. Many times only tentative decisions can be

made pending periodontal treatment, caries excavation, root canal therapy, etc. It is safer to plan inconclusively if certain teeth are questionable, pending their final disposition. If questionable teeth are given a favorable prognosis, their strategic position should be studied so that if their loss may be expected at some future time, provision can be made to avoid the necessity for re-doing the work.

The patient must be educated as to the findings of the dentist. This is done in a nontechnical way, so that the explanation is simple and brief. The problem of patient education is a complex one, which, fortunately, has been receiving more and more thought and attention in recent years. If it is not done properly, much necessary dentistry will be left undone, and many patients will be lost.

Fig. 3

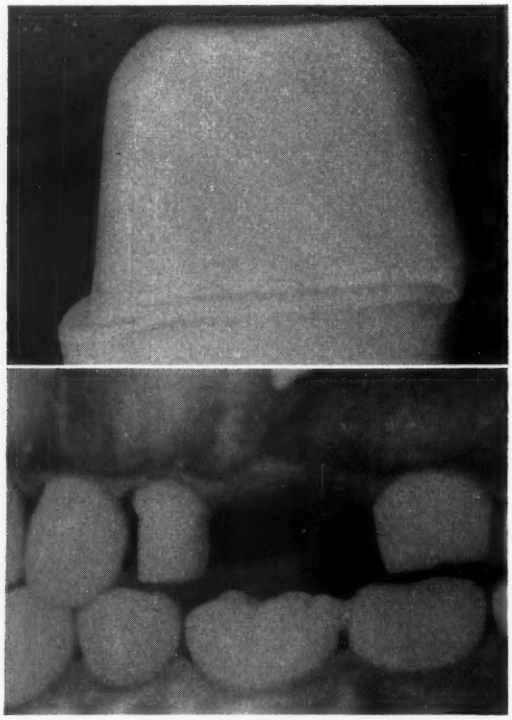

Fig. 4.

Fig. 3.—Plaster cast of the veneer crown preparation.
Fig. 4.—The completed preparations. Note the occlusal clearance.

FIXED BRIDGEWORK BY THE DIRECT METHOD

The objectives of a good fixed bridge are:

1. The abutment castings must have excellent marginal fit. These margins should extend halfway under the gingival sulcus, with no tissue impingement.

2. The occlusal relationship of the abutment castings and pontics should be in harmony with the rest of the occlusion in centric and all eccentric positions.

3. The contour of the abutment castings should be within normal limits.

4. The buccolingual diameters of abutment castings should be narrowed. The pontic should be no more than two-thirds the width of the tooth which it replaces. The occlusal tables should be carved with escapeways for food.

5. Embrasures should be wide, with a small oval ridge contact of the pontic. There should be no soft tissue impingement.

6. Solder joints should be high and broad. A minimal amount of solder should be used, consistent with strength.

7. Esthetics, an important consideration, should never sacrifice strength.

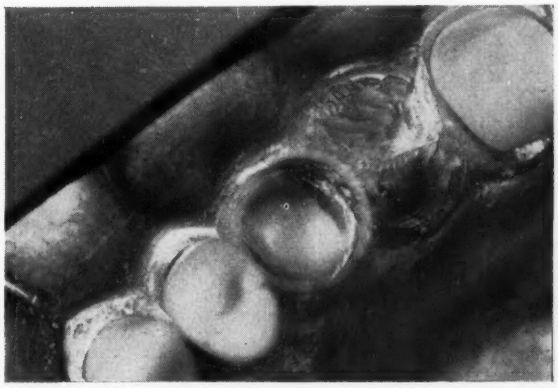

Fig. 5.—Selection of the copper band.

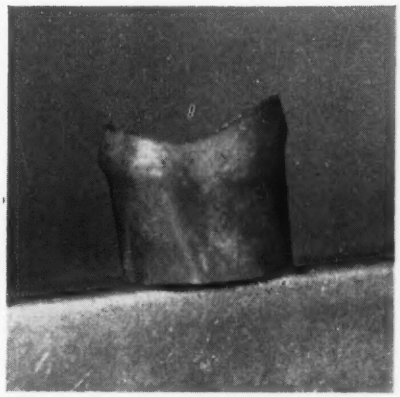

Fig. 6.—The festooned and shaped copper band.

DISADVANTAGES OF THE INDIRECT METHOD

1. It is difficult to determine the precise finishing line of a casting from a die.

2. The introduction of the additional step of die construction creates additional possibilities for error.

3. It is virtually impossible to achieve an *exact* replica of tooth and jaw relationship no matter what technique is used for cast construction.

4. Similarly, soldering from a cast can produce "rocking" bridges even with meticulous technique.

It is my conviction that the more we do in the mouth, the less chance there is for error, and the better are our results.

The abutment of choice is one with full coverage, using acrylic veneer and cast crowns.

Speed is no criterion, per se, of good technique. However, if we can employ a technique which achieves good results quickly, we should consider it carefully. The greatest "advantage" to the indirect technique is the apparent saving of chair

Fig. 7.

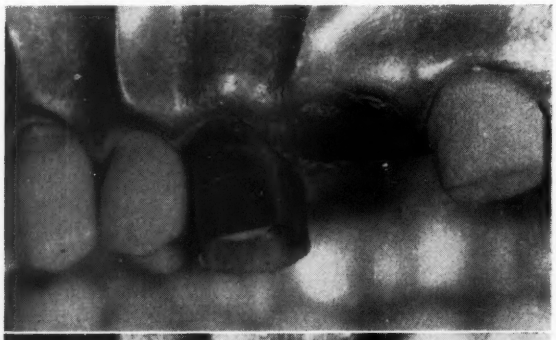

Fig. 8.

Fig. 7.—The band fitted on the tooth.
Fig. 8.—Making the impression.

time in a busy practice. However, when we consider the proportion of poorly fitted castings, overextensions, lack of or excess of occlusal contact, etc., in work done by this method, there may not be so much time saved at that. The direct method provides a quick, accurate solution to the difficult problems presented by even the simplest fixed bridge. The method herein described can be utilized for any size bridge, from a simple two-abutment-one-pontic restoration to a full maxillary or mandibular splint.

THE DIRECT TECHNIQUE

To illustrate the procedures used in the direct method for making fixed bridgework, the restoration of an upper first molar will be described. The anterior abutment will be an acrylic veneer crown. The posterior abutment will be a full gold cast crown (Fig. 1). The occlusion on the working side is adjusted to balance by grinding the high spots on the buccal cusps of the upper teeth until a maximum number of teeth come into contact in this excursion (Fig. 2).

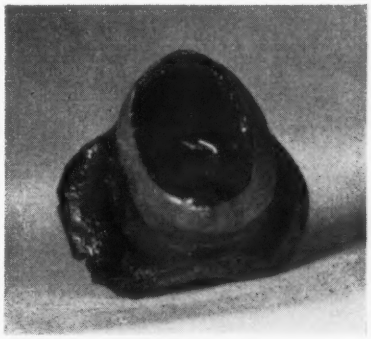

Fig. 9.—The impression removed.

Fig. 10.

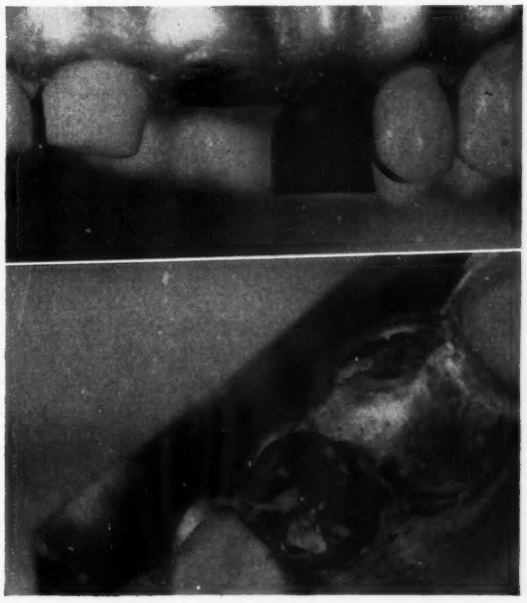

Fig. 11.

Fig. 10.—The impression with the copper band removed.
Fig. 11.—The light markings on the wax pattern are made with yellow articulating paper as a guide for the adjustment of the occlusion.

The shoulders of the preparations are extended slightly beyond the free gingiva, and run proximally, disappearing at the linguoproximal angle. The shoulder is finished in a bevel to avoid a butt-joint casting (Fig. 3).

In cases where periodontal disease has increased the length of the clinical crown, the shoulder may have to be eliminated since its creation would imperil the pulp. Also, the creation of a shoulder on most lower posterior teeth is not necessary, since the gold collar at the gingiva is rarely visible.

Fig. 12.

Fig. 13.

Fig. 14.

Fig. 12.—The completed patterns with the outline of the window for the veneer scribed on the buccal surface of the bicuspid pattern.

Fig. 13.—Softened pink baseplate wax in the edentulous area.

Fig. 14.—The occlusion and contour of the pontic is developed.

All undercuts should be carefully removed and the proximal walls paralleled or slightly tapered. The buccal and linguocclusal angles are rolled in. The preparations are made so the occlusal clearance is at least six thicknesses of thick articulating paper (Fig. 4).

A copper band three sizes larger than a tight fitting band is selected. (If No. 6 fits tightly, select No. 9, etc.) (Fig. 5.) The band is festooned, annealed,

and the gingival edge is bent in uniformly with a Peezo pliers. This provides a snug gingival fit, with uniform thickness and distribution of the wax. The smaller gingival opening permits the band to push away the marginal gingiva sufficiently to allow the wax to move into position (Fig. 6). The band should be shortened until it is slightly longer than the required length of the finished crown (Fig. 7).

Medium inlay wax is softened thoroughly in a water bath and placed in the band. The band is then seated on the tooth and finger pressure applied to provide condensation of the wax (Fig. 8). All detail must be present in the impression. If detail or proper extension is lacking at any point, the band and wax are again placed in warm water, the wax softened, and a new impression made (Fig. 9). The band is slit occlusogingivally at the area where the wax margin appears thickest. This cut is made with a carborundum disc, using light strokes and cutting *just* through the copper. With the aid of a sharp blade, the band is stripped off the pattern (Fig. 10).

Fig. 15.

Fig. 16.

Fig. 15.—The veneer filled with refractory investment.
Fig. 16.—The refractory investment base is trimmed to shape, and the window is carved. Note the retention wires.

The pattern is next trimmed with the blade to the finishing line and the thickness of the wax reduced uniformly at the margins to that of a calling card. It is then replaced on the tooth. The wax should be handled to a minimum when it is off the tooth. It should be necessary to remove it and replace it only once during the procedure to avoid distortion from handling. The tooth outline and form are quickly established with wax carvers, after which the occlusion is adjusted with yellow articulating paper (Fig. 11). The patient must be cautioned to touch lightly in order to avoid distorting the pattern. The pattern must be held in an axial direction at all times while it is being carved.

A line which outlines the extent of the window for the veneer is scribed on the buccal surface of the bicuspid pattern for guidance in carving the window later (Fig. 12).

The pontic construction is the next step. It can be done while the patterns are still on the teeth, or after the abutments are cast. Pink baseplate wax is softtened, placed in the edentulous space, and the patient's jaw is guided into centric closure. The wax is then chilled and removed (Fig. 13). The teeth of the opposing jaw and the contacts proximally are used as guides for carving the pontic. Care should be exercised to carve details of anatomy, buccolingual width, and contact fairly close to that desired for the finished pontic casting (Fig. 14).

Fig. 17.

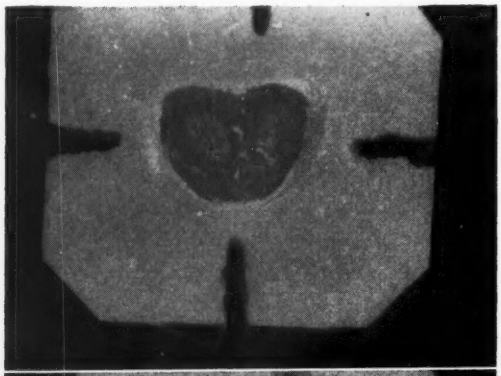

Fig. 18.

Fig. 19.

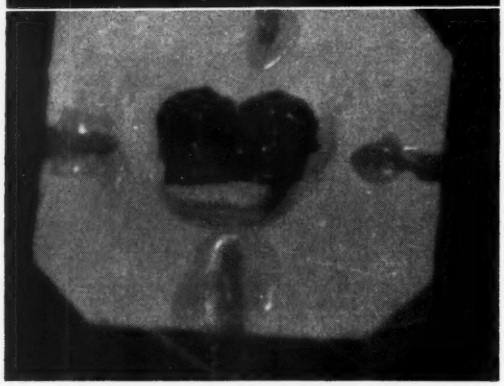

Fig. 17.—The wax pontic pattern invested in stone. Note the saw cuts in the stone.
Fig. 18.—The pontic mold reassembled.
Fig. 19.—The wax pattern for the pontic casting is formed.

The waxed pontic tooth is set aside in water and the two abutment patterns invested. Since the molar is to be a cast crown, it is invested in the conventional manner. Debubblizing solution is painted on the inner surface of the veneer pattern, and the refractory investment is carefully filled into the mold. A mound of investment is placed on a slab, and the filled pattern placed on this mound

Fig. 20.

Fig. 21.

Fig. 22.

Fig. 20.—The abutment and pontic castings are tried in the mouth.
Fig. 21.—The impression of the occlusal surfaces for an index.
Fig. 22.—The trim lines on the plaster index.

so that all margins are covered by at least 2 mm. of investment (Fig. 15). By covering all margins with investment, "flash" is prevented on the casting.

The investment base is trimmed after it has set. The buccal guide lines previously made are carefully exposed and the window is carved with suitable instruments (Fig. 16). The window should be wider inside than out. Retention wires (27 Ga. zephyr) are place strategically within the window.

The invested pattern is soaked in water for fifteen minutes and then invested in a casting ring.

The baseplate wax pontic form is invested with the buccal side up in a mound of stone. Only the buccal surface is left exposed (Fig. 17).

After the stone has set, four saw cuts are made around the sides. A sharp knife blade is inserted and the stone is carefully split apart. The wax pontic form is removed, and the mold is reassembled with sticky wax (Fig. 18). A few drops of water are placed in the mold to permit surface saturation of the inside. This is blown out after a few minutes. A thin layer of inlay wax is flowed around the inside of the mold to create the wax pattern of the pontic (Fig. 19). Retention spurs are added, the stone is carefully split off, and the pattern is invested and cast.

Fig. 23.

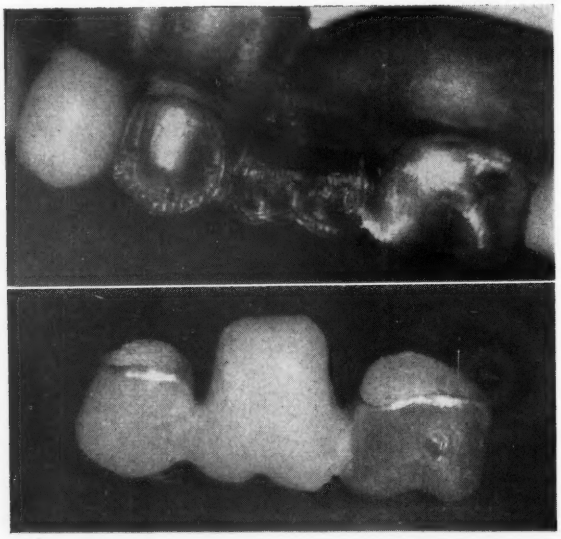

Fig. 24.

Fig. 23.—The abutments have been soldered to the pontic, and the assembly is in position in the mouth.

Fig. 24.—White inlay wax is used to make the patterns for the veneers on the abutment and the pontic.

The abutment castings are tried for fit (Fig. 20). If any high spots are present, they are touched up. It will be found that very little time need be spent in adjusting the occlusion. The occlusal anatomy of the abutments and pontics is emphasized with 558 crosscut fissure burs. These markings provide for escapeways for food and assist in accurate seating of the castings in the index.

The proximal surfaces of the castings are dried, and small blobs of sticky wax are placed on the mesial and distal of the pontic. It is lightly flamed and carefully carried to position between the abutments. The semisoft wax retains

the pontic against the abutments while the patient closes into centric occlusion. A plastic instrument brings the pontic into close occlusal contact with the opposing jaw.

Soft impression plaster is placed in a small piece of baseplate wax, and an index is made of the occlusal surface of the assembled castings (Fig. 21). The plaster index is trimmed to the lines indicated (Fig. 22). The trim lines should be at least one millimeter short of the buccal and lingual occlusal angles of the castings so that their seat in the index can be accurately determined. The occlusal carvings of the castings provide accurate keys for their seats in the index.

Fig. 25.

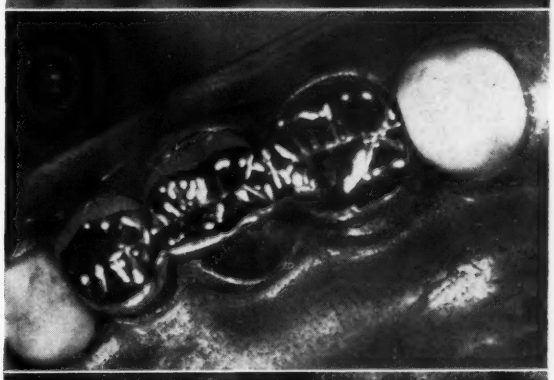

Fig. 26.

Fig. 27.

Fig. 25.—Final carving of the veneer patterns. The gold nodule on the molar casting was placed there just prior to investment of the pattern. It is used to engage a crown remover during try-ins and is removed just prior to final cementation.

Fig. 26.—Occlusal view of completed bridge. Note the buccolingual diameters, broad solder joints and anatomic detail.

Fig. 27.—The completed bridge in working side balance. The embrasures are wide to provide easy accessibility for cleansing. The soldering contacts are broad and high. The ridge contact of the pontic is close but without pressure.

The assembly is invested in soldering investment and soldered in the conventional manner (Fig. 23). The soldering contacts should be high with a minimal amount of solder used consistent with strength. In multiple abutment cases only every other joint should be soldered with each index. By returning to the mouth for a new index each time a soldering operation is completed, the discrepancies created by shrinkage of the solder are reduced to a minimum.

The gold is flash plated and undercuts in the window portions are emphasized with small wheel burs.

It should be noted that up to this point it has not been necessary at any time to resort to the use of casts in constructing the bridge. The registration of the saddle area is also accomplished without resorting to cast construction (Fig. 24).

White inlay wax is built up into the veneer window and overbuilt onto the pontic framework. The saddle portion is deep-pooled with a hot spatula, and the assembly is quickly seated in the mouth.

Final waxing is done both in and out of the mouth. The buccal anatomy is slightly overemphasized to allow for acrylic finishing later on. Wide embrasures are created on the proximals of the pontic wax (Figs. 25, 26, 27).

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FIXED BRIDGEWORK

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IN DISCUSSING fixed bridgework, no attempt will be made to enlarge upon so-called "correct procedures," but rather to report upon certain procedures which in my own experience have been found satisfactory and stable. This, after all, is the only thing of value any practitioner can bring to the family round table.

Since every mouth presents its own peculiar set of health conditions, and since these conditions are interpreted by every operator from the background of his own particular training and experience, it seems unwise to lay down any hard and fast rules as to what is desirable or undesirable in any one type of restorative work. There is no desire to condemn absolutely any one of the various types of removable or fixed bridges which have been devised to meet special needs. Merely, I would say that in my experience the fixed bridge, where indicated and where properly constructed, has been found to be the most successful restoration, not only from the viewpoint of health and natural function, but from the viewpoint of appearance and lasting qualities. The fixed bridge is the easiest to care for, comes nearer satisfying the patient's pride and peace of mind, and seems more nearly a part of his natural make-up than any removable appliance.

PROCEDURE

In approaching the individual case, the diagnosis is made through the use of (1) accurate casts mounted so as to allow for a satisfactory study of the existing occlusion; (2) a complete roentgenographic examination; and (3) adequate notes of conditions observed in the mouth and the history of the case obtained from the patient.

These are the fundamental steps in gathering the material out of which our recommendation for restoration is made.

Out of this material, two groups of cases arise: those favorable to bridgework and those unfavorable to bridgework. In one group, the occlusion is harmonious and efficient, or can be made so without excessive destruction of tooth structures. In the other group, harmony and restoration can be established only by employing a general reconstructive program. Too much emphasis cannot be given to the necessity for a favorable occlusion. Disregard of this fact explains many failures of both fixed and removable bridges.

The supporting bony structures also play an important role in the success or failure of bridgework. By means of the roentgenographic diagnosis and a study of the conditions observed in the mouth, the nature of the bone factor may be

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closely determined. Additional stress is imposed on any tooth which serves as an abutment, and the adequacy of the supporting bony structures to withstand and counteract these added stresses should be a prime consideration in planning restorations.

Another essential is regard for the health of the dental pulp. Normal pulps decrease gradually in size, and the dentine becomes more consolidated as the age of the patient advances. This decrease in pulp size makes possible the employment of fixed restorations where a younger pulp would be indisposed by it. This does not rule out the necessity of always making certain of the pulp's size and position, and the degree of calcification by roentgenographic diagnosis, and for determining the pulp's response to diagnostic stimuli.

For the purpose of diagnosis, I prefer the reaction to the thermal change induced by a pointed piece of ice. The response of a normal pulp closes immediately, while the response of a degenerating pulp lingers upon removal of the stimulus. A delayed but definite response may be expected if the dentine is thick and well calcified.

In my practice, I do not hesitate to make the necessary preparations for bridge retainers on vital teeth, either with or without caries or fillings, if in my judgment the evidence aforementioned seems to assure favorable conditions. Shallow preparations, the elimination of frictional heat, and the proper treatment and protection of the cut dentinal surfaces will reduce the amount of irritation to a point where the chance of pulp degeneration is almost negligible. The cutting of sound tooth structure is limited to the amount required for a proper outline, retention and a resistance form, and to permit the placing of retainers from a common direction.

STRUCTURAL MATERIALS

Hard gold alloys are essential to the strength and solidity of a fixed bridge. The rigidity of these alloys is sufficient to maintain the proper relation to the walls of the prepared tooth, and adequate strength is secured without undue thickness in the retainer.

Hyperocclusion due to the unequal wear of tooth structure and metal requires correction regardless of the degree of the hardness of the alloy employed in the restoration.

The amount of strength and retention required in a retainer varies under different conditions. The degree of torque and strain to which a retainer will be subjected depends upon the length of the bridge, the mobility of the abutment teeth, the occlusion present, and whether or not the broken-stress principle has been employed in the construction of the bridge.

RETAINERS

In the accepted types of retainers, retention is obtained by close adaptation to nearly parallel walls, the variation from absolute parallel being sufficient only to permit the withdrawal of the pattern and the subsequent seating of the restoration. Retention is also obtained by grooves, locked grooves, and by pits for pin anchorage.

Whatever the condition of the abutment teeth, whether with or without caries or fillings, it is of the utmost importance that the preparations provide amply for the mechanical retention of the bridge retainers. Such preparations test the ingenuity and skill of the operator in employing the various retentive features, and in making appropriate modifications of what are considered to be standardized preparations.

Complete crowns and partial veneer crowns are the favored type of retainers for the majority of fixed bridge restorations. The complete crown gives the maximum retention and strength, and is particularly indicated for bicuspid and molar teeth with short crowns or where there has been extensive loss of tooth structure.

The partial veneer crown is employed on anterior as well as posterior teeth. A well-designed and accurately made retainer of this type offers ample strength and retention. Labial and buccal margins of partial veneers may be placed where they are practically invisible. The crown type retainers completely or partially surround the abutment teeth and tend to strengthen them.

Many writers on this subject advise limiting the use of inlays as bridge retainers to those cases where only one tooth is replaced, and where a stress-breaker key and key-way connector are placed in one of the retainers. However, in the majority of fixed bridge restorations a soldered union to each retainer is preferred. With such construction, the abutment teeth support each other and the imposed stresses are favorably distributed. The rigid type connector is especially indicated where there is more than normal mobility of either of the abutment teeth. I have made many posterior fixed bridges replacing one or two teeth, where inlays served as the retainers on one or both of the abutment teeth, and with a soldered union to each retainer.

PREPARATIONS

The preparations for such retainers differed from typical MOD inlay preparations particularly in the treatment of the proximal surface adjoining the edentulous space. On this surface and where the conditions are favorable, the Knapp slice-lock, or box preparations with shallow channels cut in the lingual and buccal walls will prevent the inlay from springing or bending away from the axial wall. Buccal and lingual groove extensions also add to the retentive value of inlays as retainers.

The slice-lock preparation for molars and bicuspids gives a high degree of retention. Its use is limited to sound or essentially sound teeth. The crowns must be of sufficient length and in such a condition as to permit the making of locked grooves in solid dentine not less than two or three millimeters in length.

Where the crown of an abutment tooth is less than average length, the locked groove principle may be used to increase the retention of posterior partial veneer crowns and anterior partial veneer crowns, if the teeth are sufficiently wide labio-lingually.

We have incorporated certain mechanical retentive features in our preparations, the full value of which can be had only by assuring that the completed retainers are accurate complements to the prepared teeth.

WAX PATTERNS

Improved wax pattern and casting procedures have contributed much to the success of these items. By the proper application of the available knowledge of the physical properties and behavior of the materials employed, techniques have been developed by which accurate castings may be made with satisfying regularity.

These castings not only will provide correct marginal adaptation, contour and occlusion, but will offer a certain degree of frictional wall resistance. The desirability of such resistance to displacement for fixed bridge retainers is readily apparent. Adequate retention and strength may be obtained without undue sacrifice of tooth structure.

The type and the quality of fixed bridgework varies greatly within the profession. One man's standard of judgment as to what constitutes a satisfactory restoration may be far above or far below another's. The personal touch is undoubtedly an important factor in securing the best results with any chosen technique. Wax patterns may be made with a high degree of accuracy by either the direct or the indirect method, and the well-equipped dentist will have both methods at his command.

HYDROCOLLOID TECHNIQUE

The hydrocolloid technique, introduced by A. W. Sears, has been a noteworthy achievement in the field of restorative dentistry. For many operators this technique has improved the quality of service and at the same time it has reduced the amount of chair time, as more work is delegated to the technician. This is one way of making good dentistry available to many more people seeking the best. Wherever and whenever good workmanship can be brought to many patients rather than withheld for the fortunate few, a great boon has been achieved. This should ever be our goal.

The hydrocolloid technique is particularly advantageous in those cases where a general reconstruction is required. With the dies mounted on an articulator, the restorations of the teeth of both arches with proper occlusal anatomy may be accomplished in a single undertaking.

Dies are unquestionably a convenience in making wax patterns where the access is difficult, where there has been extensive loss of tooth structure, and for tipped or malposed teeth.

However, in making impressions it is well to remember that no material has absolute elasticity. There is always a residual permanent set, and permanent deformation may occur under stress. Granger[1] aptly points out, "The chief problem involved in taking accurate hydrocolloid impressions is distortion caused by excessive deformation of the material in removing the jelled impression over deep undercuts. The greater the bulk of material, and the less the percentage of deformation required for removal, the less danger of distortion in the finished impression."

It is obvious that the chances of distortion of an impression are lessened where the margins of the preparations are extended to include some of the extreme convexities of the teeth. Such preparations are applicable for retainers for many posterior bridges.

In the visible portion of the mouth the matter of appearance is an important consideration. The informed public is steadily becoming aware of the best in dentistry, and restorations which the casual observer commonly is unable to detect afford patients a vast satisfaction.

The requirement of extension for prevention can be met without the display of metal. The labial margins for anterior partial veneer crowns are placed just lingual to the labial enamel plate. Shallow box preparations on the mesial surfaces of other visible teeth will provide the proper extension at the proximo-gingival angles, and will permit placing the mesio-buccal margins where metal will not be noticed.

Such preparations do increase the difficulties of making an accurate hydrocolloid impression. The impression material engages anatomic undercuts of varying degrees of curvature. The limited space between the proximal wall of the prepared tooth and the convex surface of an adjoining tooth, when it is in position, allows for but little impression material in this area.

DIRECT METHOD

For these preparations I employ the direct method of making wax patterns. The appearance of the completed restorations outweighs the admitted convenience of the indirect method.

Correctly placed labial margins and proximal grooves on preparations for anterior partial veneer crowns require that the wax pattern or the impression be removed in a slightly lingual direction. Here the advantage is with the direct method.

With the experience to develop one's aptitude and skill, a systematized procedure, and a well-trained assistant, direct patterns can be made with precision and dispatch. As in all pattern making, the operator must take into account the shrinkage of wax due to thermal change, the elasticity of wax, and the molecular tension developed within the wax in making the pattern.

For certain restorative procedures, I use a combination of the two methods. The castings made from direct wax patterns are in position on the teeth when the complete hydrocolloid impression is made. These castings are then removed from the teeth and anchored in the impression. Wet asbestos is placed about each casting and low-fusing metal at 117 degrees is poured to form a supporting base. Then die stone is vibrated into the impressions of the other prepared teeth, and the entire working cast is completed.

SUMMARY

The chief essentials to satisfactory fixed bridgework seem to be (1) a mouth in which a favorable occlusion is present or in which conditions are favorable to bringing about this harmonious state, (2) absolute thoroughness in making roentgenographic and other diagnostic examinations, and (3) the maximum of care and attention to details in making retainers on the abutment teeth.

REFERENCE

1. Granger, E. R.: Unpublished data.

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Cleveland, Ohio

MOUTH RECONSTRUCTION

THEODORE S. SLOANE, D.D.S.

New York, N.Y.

RECENT investigation by Howell and Manly[1] has produced the fact that a force of 200 pounds can be generated in a simple closure of normal dentition. It is our problem to convert this force into a useful and productive ally. The conversion, however, cannot evolve from a minute examination of the debris of destruction but rather from a scientific resolution of the forces involved in function. Since we cannot control the amount of this force per se, we can produce a regulating effect by distributing its reception over all the teeth. To control the potential damage of masticatory force, all occluding surfaces must be related so that they are in positive contact during all contacting chewing motions. Only then will we have supplied an enduring reconstruction. To accomplish this, we must be prepared to duplicate the variety of patterns of mandibular motion.

In the early days of our profession, attempts were made to analyze the motions made during mastication. Gysi wrote of the rotational center of the condyle. In later years, Hanau[2] and others attempted to locate and duplicate this center. Finally, in 1925, the Gnathological Society of California[3] demonstrated that a fixed point of rotation could be obtained clinically and utilized in restorative procedures. The rotational centers of the condyles can be determined and transposed to the rotational centers of an instrument. This determination has been demonstrated to be accurate and consistent, and represents the first step in scientifically duplicating masticatory function. The rotational centers have been designated as the hinge axes.

Some confusion has arisen as to whether the hinge axis is a component of masticatory function. Actually, the hinge axis is not a component of function. We do not chew with the hinge axis. It is the designation of one portion of mandibular motion, and is utilized as a fixed reference point which can be defined clinically and transferred to an instrument. The clinical procedure to determine the hinge axis is briefly as follows:

> An appliance is cemented to the teeth of the lower jaw. Adjustable pointers are then located in the region of the condyles. By a process of trial and error, each pointer is adjusted until it merely rotates in position when the mandible drops open and closes. This indicates the point of rotation of the condyle. These hinge axis points can be fixed permanently on the skin by tattooing.

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There has been discussion as to the influence of the musculature on this determination. The muscles and ligaments control the motion within the mechanical limits of the joint configuration. Since numerous trials have always produced the same single point of rotation, we know that in each case the musculature exerts a constant influence. These muscles and ligaments do not play the governing role of position. Their part is akin to that of the engine belt that spins a diamond stone. In this rotational relationship, the muscle influence is one of rate or speed of motion in the arc of closure.

When the rotational centers have been located for both condyles, two points of reference are thereby established. If we arbitrarily choose a third point of reference on the face and relate all three points to each other, we will have established a plane of reference. When this plane of reference is accurately transferred to the articulator, we can relate casts in the instrument exactly as the dentition is related in the patient. Since the rotational centers of the patient and the instrument coincide, we know that the casts will duplicate accurately the relationship found in the mouth at any degree of opening.

The advantages of this are manifest. We have located and duplicated the elusive centric closure because the casts on the instrument cannot deviate from this arc of natural closure. Secondly, we can determine the necessary vertical dimension and, if indicated, alter this vertical opening without returning to the patient. When the plane of occlusion is established and the teeth are properly aligned, we can be certain that we have supplied the patient with occluding tooth surfaces which will insure the maximum distribution of the force generated by a centric closure.

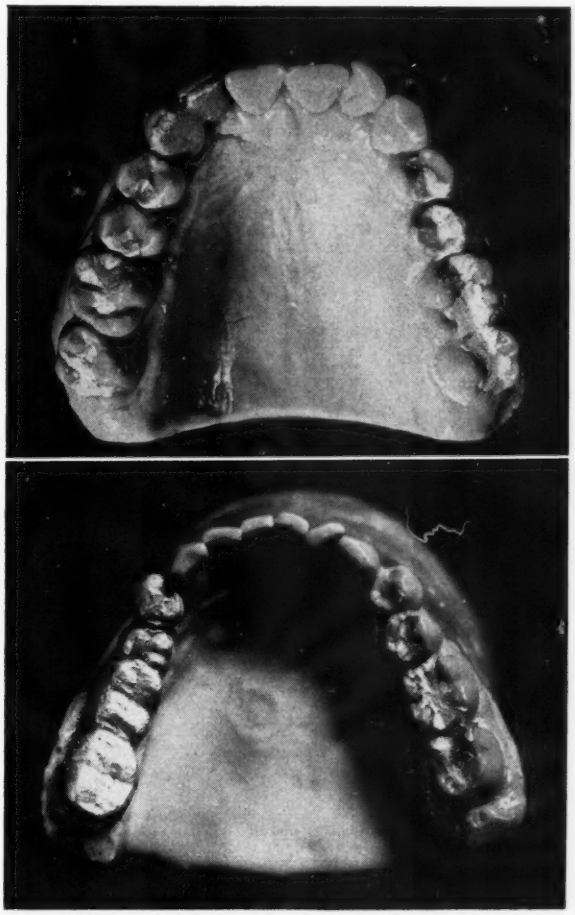
To return for a moment to the established points of reference, each serves the invaluable purpose of orientation to a landmark by which we can further study and duplicate mandibular motion. If we trace the displacement of these points during function, the resultant tracing will record the pattern of the pathway in which the condyle moves. If these tracings are recorded in all three dimensions simultaneously, we will have traced the displacement of the condyle in its entirety. The tracings can then be removed from the patient and oriented to an adjustable articulator in accordance with the plane of reference described before. The tracings then serve to govern the adjustment of the articulator. When the instrument accurately follows the tracings created by the patient, we will have reproduced his particular motions of mandibular function.

This is not a theoretical consideration. The procedure which I have just outlined has been successfully employed by practitioners for the past decade. I am not particularly concerned with a detailed description of the method but rather with the need for a basic understanding of masticatory forces which are so often the crux of a successful reconstruction. For when we use an instrument which can accurately duplicate function, then and only then can we successfully relate occluding surfaces of teeth so that they will remain in positive contact during all excursions. Instead of requiring the dentist to spend endless hours of work at the chair, it can be successfully accomplished in the laboratory by technicians. The plane of occlusion, the curve of Spee, and the anterior guidance can

be related to cuspal form. These are factors that must be integrated in the pattern of occlusal relationship predicated on the functional requirements of the individual patient.

Mandibular position and motion do not accommodate to changes in dentition. For all practical considerations, the movements made by the mandible in mastication are involuntary. Think for one moment of the number of strokes involved

A.



B.

Fig. 1.

in comminuting one bolus of food. Multiply this by the number of mouthfuls that constitute a meal, and then by the number of meals in a month. The total is tremendous. These motions cannot be premeditatedly controlled. In both our routine restorative procedures and in mouth reconstruction, it is our goal to furnish our patients with enduring restorations. The only way this can be

done successfully is by distributing the load of function among all components, whether the contact be in centric occlusion or during any other mandibular excursion.

CASE 1

Past Dental History.—The chief complaint of the patient was her inability to chew on the left side. All her teeth were "getting loose" and she was afraid of losing them. Several attempts had been made to correct the occlusion by grinding. However, this procedure had tended to produce no effects other than to make her more uncomfortable.

Clinical Observations.—The patient was a woman aged 45 years, with a normal complement of teeth. The gingival tissues were injected, and there was marked recession around the anterior teeth. The buccal mucosa and tongue were normal. The missing teeth included the lower left second premolar, and the first molar, all third molars, and the upper right lateral incisor (Fig. 1). The teeth of the lower left posterior quadrant and upper anterior region were quite mobile. The other teeth were mobile to a limited degree. There were prematurities present in a centric closure, and the excursions showed great inefficiency in distribution of the chewing forces. Roentgenographic examination showed generalized alveolar resorption and deep pockets, particularly between the upper right first and second molars. The resorption around the molars was just short of bifurcation and trifurcation involvement. In the anterior regions, the bone had retreated at least one-half of the root length.

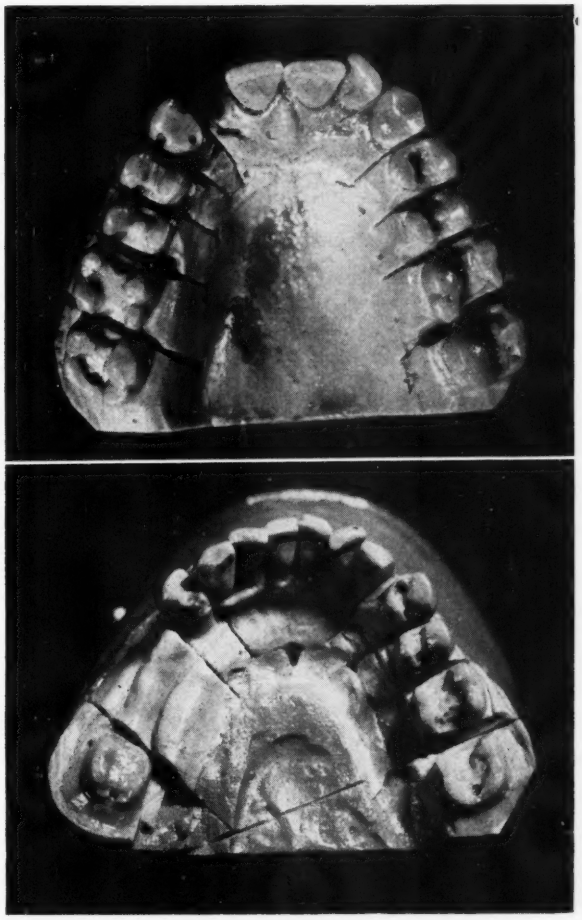
Diagnostic Findings.—A hinge axis determination was made, and clutches constructed. Registrations were made and casts mounted on the adjusted gnathoscope. Centric closure on the instrument demonstrated the distinct prematurities seen clinically. As the patient moved from centric into a right lateral excursion, the tooth contact was solely on the anterior teeth of that side, with no balancing contacts present. In left lateral excursion, there was contact between the premolars for the first millimeter of motion, and then the contact shifted to the anterior teeth of that side. In this excursion, there was balancing contact within two millimeters of centric position, but only on the second maxillary molar. In protrusive, there was no posterior contact at all. Lack of supportive contact during function was producing a great deal of trauma on the anterior teeth.

Treatment.—The teeth were prepared for the reception of castings, and hydrocolloid impressions were made. Casts (Fig. 2) were then mounted on the gnathoscope, and patterns were waxed to insure contact during all excursions. After the castings were made, they were returned to the instrument and adjusted for contact and marginal adaptation. Any discrepancies were then corrected so the occluding surfaces of the castings remained in positive contact during function. The castings (Fig. 3) were seated in the mouth with temporary cement for a short period of time, and then permanently cemented.

Results.—Correct masticatory relationships were established so the patient could function with full efficiency, and with proper supportive balance to insure the prolonged retention of all components. The patient reported an ability to chew

anywhere in her mouth with equal ease and comfort. She has since been seen periodically for her regular prophylaxis. The gingival tissue has now returned to a normal healthy pink tone, and the anterior teeth have lost their marked mobility.

A.



B.

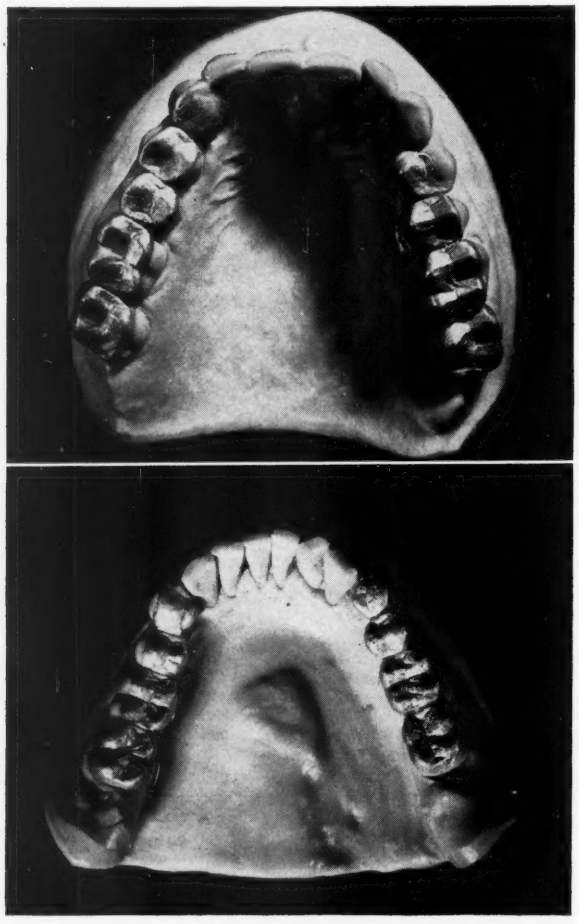
Fig. 2.

CASE 2

Past Dental History.—This patient had been under observation for the past ten years. The only complaint was the gradual destruction and consequent recession of the gingiva of all the anterior teeth. Various methods had been employed to avert this condition. Excellent oral hygiene and reparative dentistry maintained a high level of mouth cleanliness. However, the recession continued, and the exposed root surfaces became eroded.

Clinical Observations.—The patient was a man 30 years of age. There was a full complement of teeth with the exception of the maxillary third molars and the mandibular left third molar. The buccal mucosa and tongue were normal. The anterior gingiva was hyperemic and edematous. Recession had progressed so that one-third of the root surfaces were exposed. In the buccal areas of both the maxillary and mandibular left canines and premolars, marginal clefts were present. Deep cervical erosions were present. The teeth of this area were slightly mobile.

A.



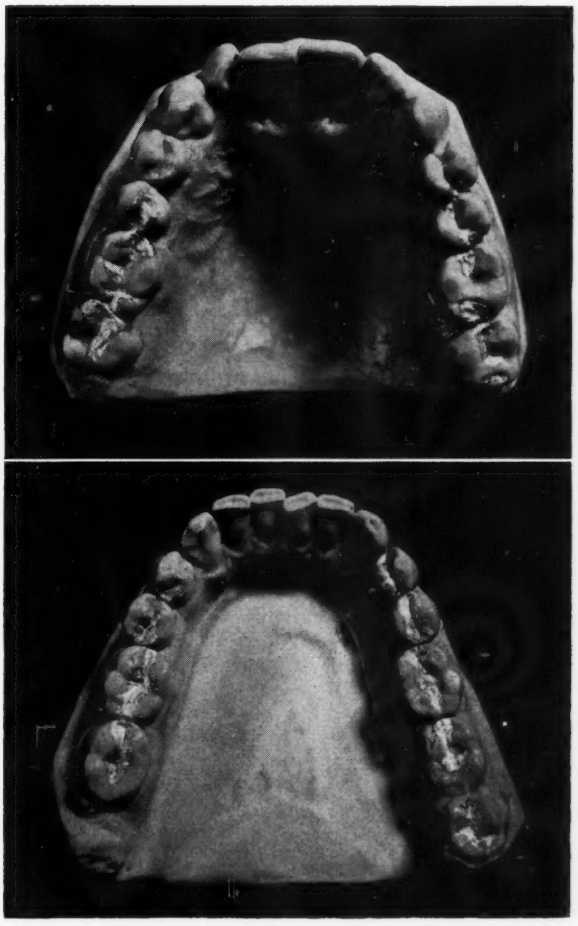
B.

Fig. 3.

Centric closure was good, but there was an edge-to-edge relationship anteriorly. The patient observed that he was conscious of his anterior teeth striking "heavier than the back ones." His history revealed that this had been relieved by grinding, but each time the feeling recurred. In left excursions, the only contacts maintained were the canines and premolars, with the second molar supply-

ing the only balancing contact present. In right excursions, the only contacts were in the anterior region and distal half of the first molars, without any accompanying balance. Roentgenographic examination revealed distinct alveolar resorption in the above-mentioned regions.

A.



B.

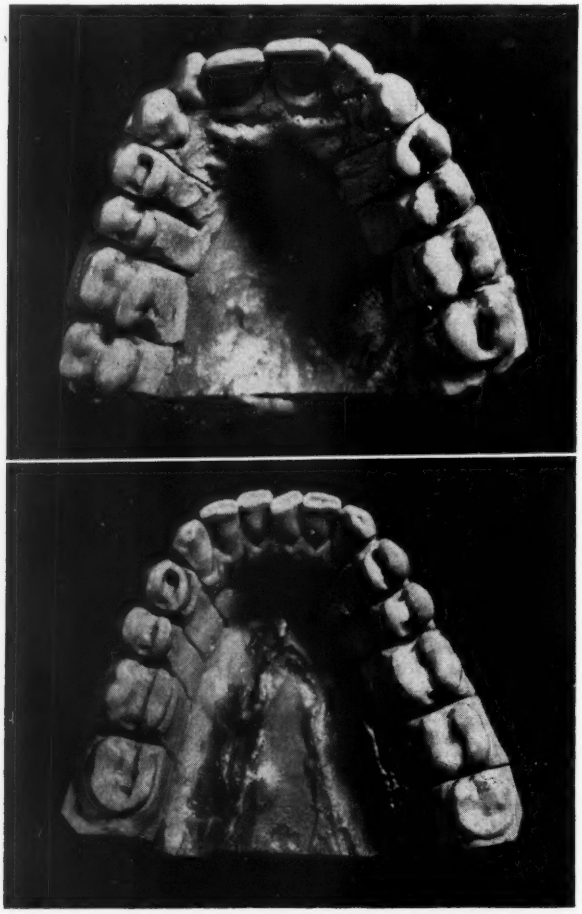
Fig. 4.

Diagnostic Findings.—A hinge axis determination was made. Clutches were constructed, and registrations made. Accurate casts (Fig. 4) mounted on the adjusted gnathoscope revealed that in centric closure no posterior prematurities were present. The anterior teeth met positively along the full length of each incisal edge. In left excursions, the only contact was in the canine and premolar regions. The molars engaged only at the position of centric closure. The only balancing contact was the lingual cusp of the maxillary right second molar which did not engage except within 2 mm. of centric position. In right excursions, the

only contacts were the right anterior teeth and the distobuccal cusp of the first molars which were engaged only within 2 mm. of the centric position. There were no supportive balancing contacts present.

It was clear that no amount of tooth grinding could supply an adequate distribution of the functional load. Relieving the anterior teeth would result only in further extrusion until contact was re-established. The posterior occluding sur-

A.



B.

Fig. 5.

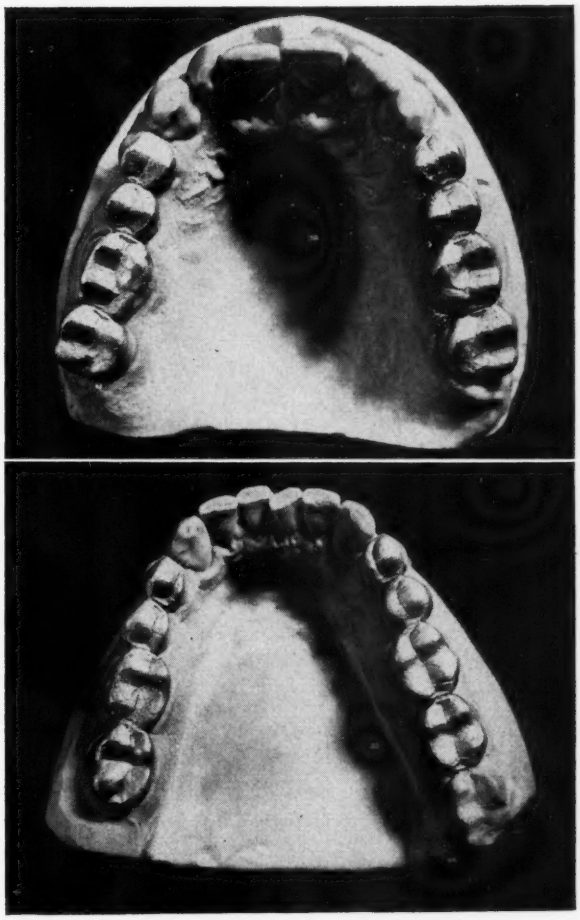
faces had to be reoriented to integrate with the existing edge-to-edge relation of the anterior teeth, and it was necessary to develop supporting balance to further reduce the trauma.

Treatment.—The posterior teeth were prepared, and hydrocolloid impressions were made. A transfer was made, and the working casts (Fig. 5) were mounted

on the gnathoscope. Patterns were waxed so there was positive contact during all excursions. Castings (Fig. 6) were adjusted, seated, and cemented.

Results.—It was interesting to observe that when the forces were distributed equally during all excursions, the traumatized gingivae regained a healthy tone, and the areas of inflammatory reaction subsided. The patient reports great ease and comfort in function and periodic roentgenographic examination has revealed no further resorption.

A.



B.

Fig. 6.

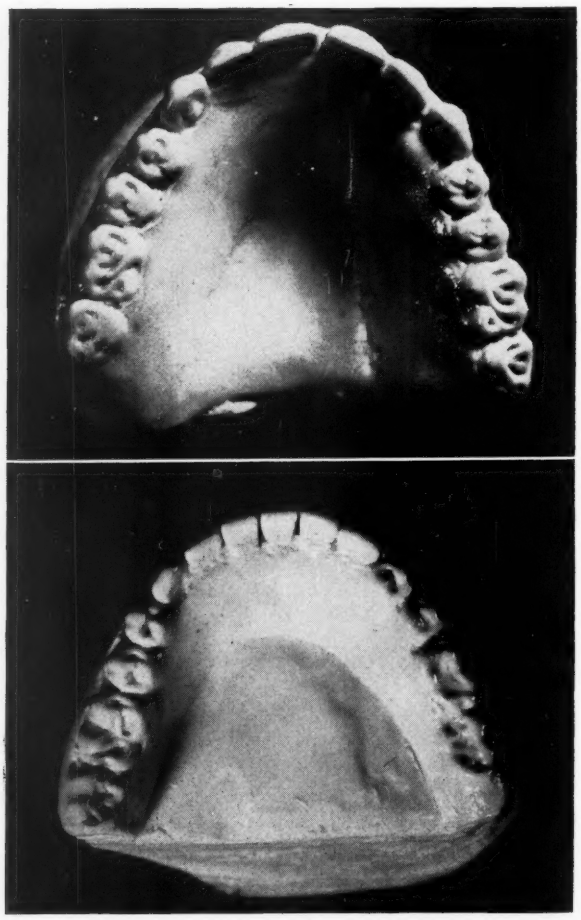
CASE 3

Past Dental History.—The patient's chief complaint was his inability to chew comfortably. He complained that the dentures did not stay in place during mastication. The remaining natural teeth had been removed three years previously, and he had had several sets of dentures made. He was referred by his physician

for an evaluation of his masticatory efficiency because his medical history included a chronic gastrointestinal complaint of undetermined origin.

Clinical Observations.—The patient was a man aged 39 years. The maxilla was normal in appearance with good firm ridges. The mandible exhibited marked alveolar resorption. No ridge was present anteriorly except for a thin,

A.



B.

Fig. 7.

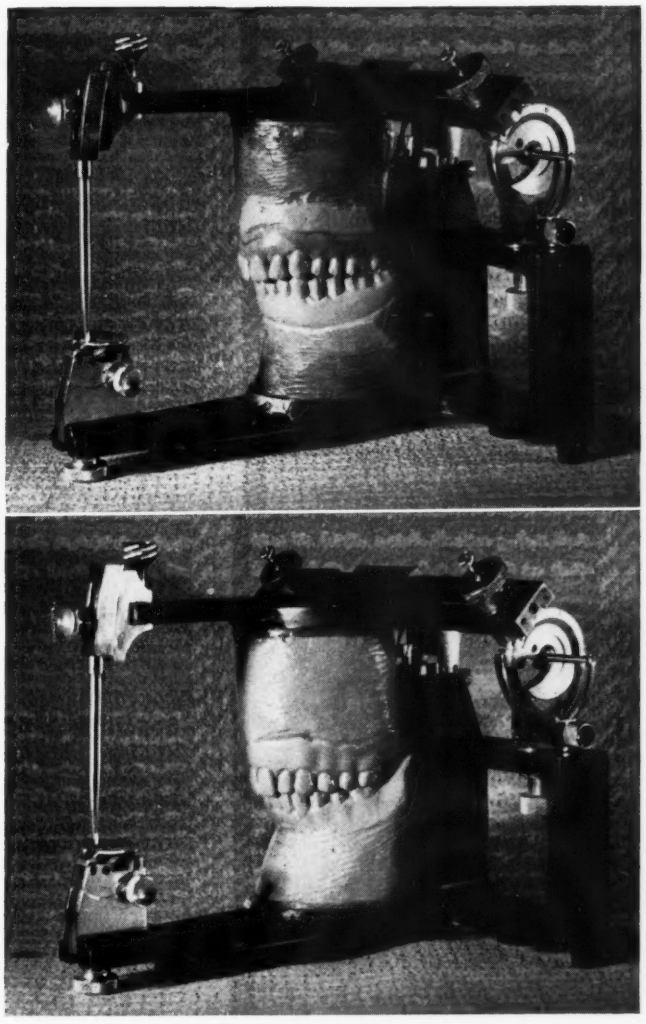
flabby band of tissue. The tissue in this region was hyperemic, slightly edematous, and painful to digital pressure. Roentgenograms showed the bone to be normal except for marked resorption of alveolar crest of the mandible.

The patient's dentures were replaced and examined for stability and function. Stability was present to a limited degree when they were tested by digital pressure. When the patient closed into centric position, the mandible had to move

several millimeters forward to interdigitate the posterior teeth. All lateral excursions tended to unseat the dentures and traumatize the supporting structures.

Diagnostic Findings.—A hinge axis determination and transfer were made. Casts were mounted, and clutches were constructed. Registrations were made, and subsequently casts of the patient's dentures (Fig. 7) were mounted on the

A.



B.

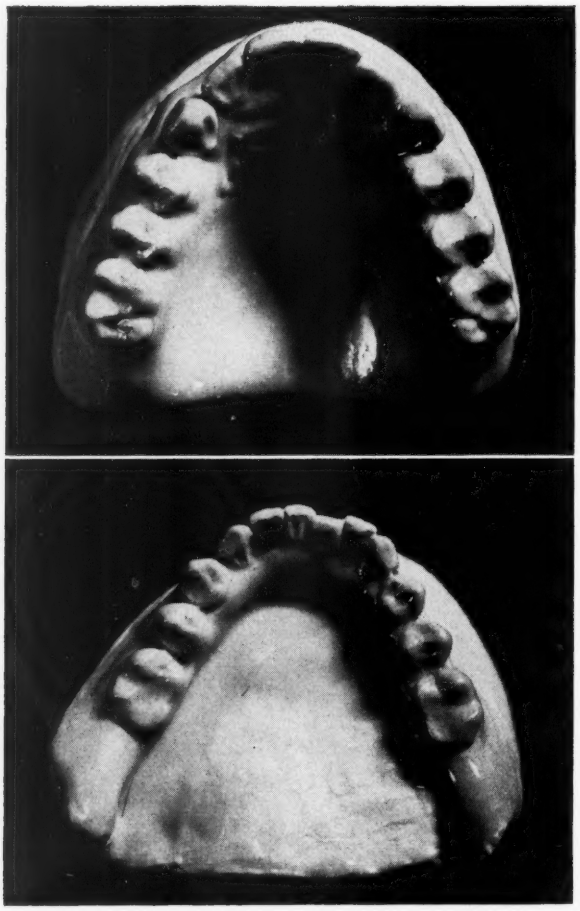
Fig. 8.

adjusted gnathoscope for further study (Fig. 8, *A*). In centric closure, there was no tooth to fossa relationship, and it could be obtained only by sliding the lower cast into a protruded position. There had been no adequate compensation of cusp form for the patient's wide Bennett shift to the right. This single factor accounted for a great deal of the instability present. All cusps had been

ground in relation to the protrusive position that evidently had been established as centric position. When the patient attempted any excursion, it resulted in both unseating the dentures and injury to the underlying tissues.

In view of the findings, it was recommended that new dentures be constructed.

A.



B.

Fig. 9.

Treatment.—Impressions of the denture-bearing areas were made. Accurately fitted trays were constructed, and occlusion rims were placed on them. These were seated and adjusted. This relationship was transferred to the gnathoscope (which had been set to the registrations made by the patient) by orientation of the maxillary tray to the axis-orbital plane, and a centric closure oriented the lower cast. The teeth were set up in centric occlusion and returned to the patient's mouth where adjustments were made to improve the esthetic arrangement. At this point the centric closure was carefully checked. (Fig. 8, *B*) The trial den-

tures were returned to the gnathoscope, and the posterior teeth were removed from the setup. The posterior teeth were then replaced, tooth by tooth, and ground to produce the necessary cuspal relationships in all excursions (Fig. 9). This cuspal relationship is predicated on the fact that each cusp must stay in firm contact during the full length of its activity in the excursion. After this was satisfactorily accomplished the dentures were processed and returned to the gnathoscope where any errors as a result of processing were corrected.

The dentures were inserted, and the patient was supplied with the necessary instructions as to their care.

Results.—The reaction was quite dramatic. The patient was able to masticate comfortably. The dentures were stable, and since the cuspal form had been created in accordance with his functional requirements, there was a vast improvement of his masticatory efficiency.

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Readers' Round Table

Minneapolis, Minn.

Editor, The Journal of Prosthetic Dentistry,

Your comments (**2**:569, 1952) concerning my article, "Occlusion From Rest Position" (**2**:575, 1952), are very interesting and express a number of points which are quite stimulating for discussion.

As you have suggested, the technique produces excellent results if the patient is properly conditioned. It was my desire to stress anatomy, physiology, and psychology in the article. So many of our dental procedures are on a mechanical basis that we do not consider the condition of the patient as presented and the possibilities of traumatogenic conditions. Our registrations are based upon the presentation of the patient and are many times associated with force such as a registration into wax or compound. There is also the condition of the temporomandibular joint which may affect the registration.

You mention parallelism of the ridges as being important in biting force, as well as parallelism affecting the relation of the points to the Gothic arch tracing. In the relation of the power points to the Gothic arch tracing, the registrations are at the same horizontal position, therefore the ridges are parallel whether the patient is biting in the eccentric position or at the apex of the Gothic arch.

The paralleling of the ridges in the vertical dimension is an interesting observation which is helpful in including the alignment of the anatomy. Median lines and space area for the occlusal plane to be placed slightly below the retromolar pad all seem to come in normal alignment. It is my opinion that these factors are very helpful but may not be included as the basic factor. We need to have a basic factor in diagnosis, and it is my opinion that the muscles are the predominating factor and provide the physiologic means for diagnosis.

Parallel ridges have a reference to vertical dimension. It perhaps would be more logical to say that Nature had the ridges parallel when the muscles are in function rather than making the muscles function when the ridges are parallel. The reason being that Wolff's Law states that force may determine form of bone.

To accept the Gothic arch tracing as an indicator of central position in all cases would hardly seem reasonable, as pathologic and traumatogenic conditions must be included. Due to previous occlusion, distal thrusts may be created which change the extent of the movement of the mandible. A recording may be made of a pathologic condition and this extended to the restoration.

The paper suggested that cases be conditioned and treated to correlate Gothic arch and rest position as a check step for registration. If we recognize and accept the responsibility of traumatogenic conditions, we must treat them.

In regard to the power of muscles which is not changed by the loss of teeth, although there is a different recording with natural and artificial teeth, we must consider the entire registration.

The registration of biting force is expressed as a relative factor when taking a registration. It is the same patient with or without teeth, the same ridges, same bases, same instrument, and the same time. All conditions should remain the same except changing the vertical dimension.

The poundage of biting force is an expression of resistance and provides a recording of the maximum resistance for the individual being treated. With teeth there is more resistance than with tissue; however, the same vertical would check in either case. Usually the ridges are parallel, as this is Nature's architecture in providing a form best suited for resistance at the maximum force which may be exerted.

The other factor which was stressed in the paper was the involvement of occlusion in the temporomandibular function. Many of the cases have an occlusion problem which should be diagnosed. Unfortunately, this has not been stressed in literature and teaching, and the dental profession has not generally been included in the treatment of temporomandibular joint involved cases.

At the present time there seems to be more attention directed to the temporomandibular joint problems which will extend dentistry into a greater field.

Very truly yours,

Ralph H. Boos, D.D.S.

Dunedin, New Zealand

Editor, Journal of Prosthetic Dentistry,

In your comments (**2**:570, 1952) about our article (J. PROS. DEN. **2**:633, 1952) you say that avoidable errors added to unavoidable errors will increase the total error. This is not invariably true. Errors of measurement have negative as well as positive values and are therefore to be added algebraically, that is, with regard to sign. This results in the total error being nearly always less than the arithmetic sum of the component errors.

Moreover, in multiple measurements or records no significant improvement in the accuracy of the final result follows from the use of a micrometer for measuring one dimension if a foot-rule has been used to measure another dimension of comparable magnitude. In prosthesis, the foot-rule corresponds to the expansion of plaster, the inaccuracy of trial bases, the dimensional changes in wax, the shrinkage of polymerization, and so on. The face-bow is the micrometer which cannot compensate for the defects of the foot-rule.

You say—"If the vertical separation of the casts is changed on the articulator, the face-bow is important. If cusp teeth are used, it is important - - ." Since these are precisely the beliefs which our investigation disproved, your readers, who look to you for interpretation if not for guidance, must be puzzled by a

direct editorial contradiction of a contributed article. We join them in hoping that in due course you will publish disproof of our conclusions and quantitative verification of your own feelings.

Your final comment, "that the face-bow is of value for *convenience* in mounting," we take to mean that it is quicker and easier to mount casts in an articulator with a face-bow than by hand. A face-bow transfer is admittedly a simple operation, but we deny that it makes the mere mounting of casts any easier. The general belief that it makes the mounting much more *accurate* we have already disposed of.

Yours sincerely,

F. W. Craddock
H. F. Symmons

Brooklyn, N.Y.

Editor, Journal of Prosthetic Dentistry,

I would like to make a comment on the article "Evaluation of the Face-Bow" by Craddock and Symmonds (J. Pros. Den. **2**:633-642, 1953).

The authors of this article neglect to take note that a full denture is placed on a rather movable support, the palatal and ridge mucosa.

Mathematically, it can be proved that the discrepancies are of slight magnitude if no face-bow is used, but it is suggested that these discrepancies be removed in the mouth by spot grinding. This is virtually impossible, no matter how adept an operator is in mouth spot grinding of full dentures. The slight spaces between occlusal surfaces that must be corrected for in order to attain maximum occlusal contact in all excursions would be taken up by the yielding mucosal tissue, leaving to the operator's eyes a deceiving impression of contact of occlusal surfaces of teeth. A malrelationship of this nature would be evident only in an adjustable articulator with stiff and rigid base supports.

Therefore, the authors, I think, have unwittingly strengthened the argument for the use of a face-bow in the techniques where it is utilized by proving that without it you do get discrepancies.

Sincerely,

Sol. A. Bergman, D.D.S.

ANNOUNCING

THE AMERICAN DENTURE SOCIETY PROSTHETIC

ESSAY CONTEST

A PRIZE of $100.00 is offered by the American Denture Society to the senior dental student who submits the best essay on prosthetic dentistry. This is being done to stimulate technical writing among dental students.

RULES

1. The contest is open to all senior dental students registered in any American dental college.
2. All essays are to be on some phase of prosthetic dentistry.
3. All essays are to become the property of the American Denture Society, and none will be returned.
4. The winning essay will be published in the JOURNAL OF PROSTHETIC DENTISTRY.
5. Essays must be double spaced, on plain paper with generous margins. No carbon copies or essays on onion skin paper will be considered.
6. Illustrations must conform to the standards of the JOURNAL OF PROSTHETIC DENTISTRY.
7. The essay must be worthy of publication in the JOURNAL OF PROSTHETIC DENTISTRY to qualify for the prize.
8. Essays must be postmarked by July 1, 1953, in order to receive consideration.
9. The Judges are a special committee of the American Denture Society.
10. The decision of the judges is final.
11. All essays are to be clearly marked as contest papers and sent to:

Dr. Carl O. Boucher, College of Dentistry, Ohio State University,

Columbus 10, Ohio

All contest papers will be sent by him to the committee judging the contest.

News and Notes

ANNOUNCEMENTS

The meeting of The American Denture Society will be held Feb. 7 and 8, 1953, at the Congress Hotel in Chicago, Ill.

The meeting of the American Academy of Restorative Dentistry will be held Feb. 7 and 8, 1953, at the Conrad Hilton Hotel in Chicago, Ill.

The American Academy of Implant Dentures will hold its Dedicatory Meeting on Saturday, Feb. 7, 1953, at the Sheraton Hotel in Chicago, Ill. An excellent program has been arranged. The speakers will discuss all phases of prosthetic treatment by implant dentures. The reservation fee of ten dollars should be mailed to the Convention Chairman, Dr. William E. Barb, 668 E. Maple Road, Indianapolis, Ind., before Jan. 15, 1953.

FIFTIETH ANNIVERSARY OF THE REVUE BELGE DE STOMATOLOGIE.

The Societe Belge de Stomatologie et de l' Association des Licensies et Dentistes Universitaires de Belgique will organize an International Congress in May, 1953, to commemorate the Fiftieth year of The Revue Belge de Stomatologie, their official organ. Doctor H. Priem of Gand is to be the President of the Congress. The place and the exact date of the Congress will be announced very soon.

Belgian colleagues and those from foreign countries who may have papers, table clinics, or films to present to the Congress can write to the president at 1, Place Prof Laurent, Gand.